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and

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The International Engineering Congress

Prominent engineers from 22 nations assembled last week at the Empire Exhibition at Glasgow to attend the International Engineering Congress held under the presidency of Lord Weir. Like most congresses of this type, the functions were both technical and social, the former including the presentation of some 15 or 20 Papers, and also visits to a large number of the more important Scottish engineering works, and the latter providing the usual round of receptions and the enjoyment of all the amenities offered by the Empire Exhibition.

The Congress was organised primarily by the Institution of Engineers and Shipbuilders in Scotland, and was sponsored by nine of the other leading engineering institutions of the country, including the Iron and Steel Institute. The technical scope of the Congress was very wide indeed, and most of the Papers were of the nature of general reviews. They covered such subjects as the shipbuilding industry, coal, gas, electrical generation and distribution, municipal and industrial planning, air transport and so on. As none of the Papers was discussed, the whole plane of the Congress was kept to the general rather than to the particular. Since the various subjects were dealt with on such a broad basis, this tended to the consideration of the ultimate processes and products of industry to the exclusion of the more basic aspects such as the foundry. This does not mean that there was nothing of interest to the foundryman. In fact, most foundrymen with the time to read them will find the general reviews of the coal, gas, and electrical industries of great interest and value, whilst the student of sociology and welfare will find the Papers on municipal and industrial development of special interest. More of direct concern to the metallurgist is perhaps found in the Paper by Prof. Thum, presented on behalf of the German engineers, on the subject of "Research on Materials and Modern Design." This Paper gives consideration to such factors as fatigue, notch effect and damping capacity in machine construction, and brings out points which appear to favour castings especially in iron, as compared with structures formed from the higher strength materials.

At least one recent development in cast-iron metallurgy received special attention, for Mr. Ricardo, in discussing the evolution of the modern internal-combustion engine, referred to the problem of corrosive wear and the way it had been met in part by the use of the corrosion-resistant austenitic cast irons for cylinder liners. Further, the metallurgical interest was met by the works visits, especially to the shipyards and other large engineering works, these including in many cases at least a short time spent in the foundries.

On the whole, it cannot be said that the foundry industry was strongly represented at the Congress, but there is no doubt from the brief references in the Papers that most of the engineers present realise the fundamental importance of the industry and the extent to which their own developments depend on the availability of high-quality castings. Foundrymen in their turn can learn much from the general consideration given to engineering problems and developments as given in a congress such as that just held in Glasgow.

Frettage Corrosion

One of the several hundred exhibits at the National Physical Laboratory which caught our eye during the annual inspection by the General Board was that in the Engineering Department relating to "frettage corrosion." This expression is used to designate a type of corrosion which is manifest with closely-fitting metal surfaces, such as those used in airscrew shafts, hubs of gears, fitting bolts, flanges, and so on. Engineers have noticed that the trouble occurs only when vibration is present. As a result of this action a fine reddish-brown dust—which is described by the N.P.L. as not unlike cocoa—appears between surfaces which are usually regarded as fitting so tightly that no relative movement is possible. When the surfaces are oiled or greased a reddish sludge oozes out, and in those cases where one of the metals is iron or steel, it appears as if the metals were bleeding. Furthermore, it has been found with accurately-fitting surfaces which are frequently taken apart and reassembled that the metals have sometimes become so badly pitted as to render them useless, and renewal of the parts is essential. This phenomenon, which has become known as "frettage corrosion," because the metal is "fretted" away, has mystified engineers for many years, and is now being studied in detail at the National Physical Laboratory. Certain combinations of soft and hard metals have been found apparently to reduce the effect, especially when lubricated, but so far no combination of surfaces has been found to be immune, and the problem awaits complete solution.

International Engineering Congress at Glasgow

DELEGATES WELCOMED BY SECRETARY FOR SCOTLAND

An International Engineering Congress was opened in the Conference Hall of the Empire Exhibition, Glasgow, on Tuesday of last week, and was continued, so far as the technical sessions were concerned, over Wednesday. The President of the Congress was the Rt. Hon Viscount Weir, P.C., G.C.B., and the Vice-Presidents comprised the Lord Provost of Glasgow, Messrs. E. Bruce Ball and John W. Hogg, Sir James Lithgow, Bart., Sir Frank Smith and the President of each of the following co-operating societies:—Institution of Civil Engineers, Institution of Electrical Engineers, Institution of Engineers and Shipbuilders in Scotland, Institution of Gas Engineers, Institute of Marine Engineers, Institution of Mechanical Engineers, Institution of Naval Architects, Institute of Welding, Iron and Steel Institute and North-East Coast Institution of Engineers and Shipbuilders.

Inaugural Ceremonies

Viscount Weir presided at the inaugural meeting, which was held in the large conference hall, and addresses of welcome to the delegates were given by Mr. John Colville, M.P. (Secretary of State for Scotland) and Lord Elgin (chairman of the Empire Exhibition Committee).

THE SECRETARY FOR SCOTLAND (Mr. Colville) said that Scotland took it as an honour to receive such an international gathering of engineers, and they would all do their best to make the delegates feel that their choice of Scotland was a wise one. Scots had pioneered in several branches of engineering, but they did not delude themselves by failing to recognise how much they owed to the engineers of other countries. They knew that towards the great advance engineering science had still to make, many countries would contribute, and that in the exchange of ideas amongst nations lay the surest hope of progress.

LORD ELGIN said the present Congress reminded them of the reasons which led to the organisation of the present Empire Exhibition at Glasgow. One reason was to show what a force and an influence the British Empire could be, and how the different parts of the Empire could help each other. Another reason was that they felt the Exhibition should be a meeting place for people from all parts of the world to discuss what could be done to make life fuller, happier and more pleasant than it had been for their predecessors.

VISCOUNT WEIR, who followed with the presidential address, extended at the outset a cordial welcome to all the delegates on behalf of the Institution of Engineers and Shipbuilders in Scotland. Glasgow, he reminded them, was not without experience of such congresses. Indeed, 37 years ago, on the occasion of the last great Glasgow Exhibition, an engineering conference was held which met with conspicuous success. Proceeding, the speaker said that no one was more conscious than the scientist and engineer that to-day, in many cases, he was not directing the great sources of power in Nature towards the use and convenience of man, but that he was having imposed on him a deflection from that duty, leading to the destruction of civilisation. Armaments, of course, had a measure of attraction even for the scientist, the engineer, and the fabricator, which was due to the wonderful variety of technical problems they presented, to the lack of financial limitations in their execution, and, to some extent, to the lessons which might be applied to peaceful purposes. But these attractive aspects faded into insignificance when compared with the possibility of applying the same energy, activity, and financial resources to peace-time progress.

Papers Presented at the Congress

The following Papers were presented during the Congress:—

(1) "Some Recent Developments in the Iron and Steel Industry in Britain," by A. McCance, D.Sc., and T. W. Hand; (2) "Material Research and Modern Machining Practice," by Prof. Dr. A. Thum (Germany); (3) "The Building of Ships—a British Survey," by Sir James Lithgow, Bt., M.C., D.L.; (4) "Naval and Mechanical Constructions in Italy," by General G. Rota, R.I.N. (Italy); (5) "The Use of British Coal—a Review and a Forecast," by Sir Richard A. S. Redmayne, K.C.B.; (6) "Progress of the Internal Combustion Engine during the last Twenty Years," by H. R. Ricardo, B.A., F.R.S.; (7) "Technical and Economic Developments in Electrical Engineering," by S. B. Donkin; (8) "Some Views on the Problem of Electricity Generation and Distribution in France," by E. Mercier (France); (9) "Gas—Yesterday, To-day and To-morrow," by Sir David Milne Watson, Bt., M.A., LL.B.; (10) "Recent Developments in the Gas Industry in Canada," by J. Keillor (Canada); (11) "Town and Country Planning and its Relation to Industry," by G. L. Pepler, F.S.I.; (12) "The River Clyde and the Harbour of Glasgow," by A. C. Gardner, F.R.S.E.; (13) "International Air Transport," by Rt. Hon. Lord Sempill, A.F.C.; (14) "The Central Station in One Man's Lifetime," by G. A. Orrok (America).

Paper No. (1), by Dr. McCance and Mr. T. W. Hand, deals with (*a*) "Blast Furnaces, Steel Works and Rolling Mills of Colvilles, Limited, Glasgow"; (*b*) "Developments in the Steel Industry of South Wales and Northamptonshire."

Correspondence

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

The Cricket Match

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—Owing to difficulties in arranging for the cricket ground, it has been decided to postpone the annual cricket match between the Institute of British Foundrymen and the Works Management Association to Sunday, September 4. I shall be glad if all those interested will make a note of this alteration. Further details will be circulated later.

I am still wanting players, and shall be glad if any member of the Institute of British Foundrymen who would care to help us in completing the team would communicate with me.—Yours, etc.,

J. E. HURST.

"Ashleigh," Trent Valley Road.
Lichfield.

June 27, 1938.

(*Continued from next column.*)

very favourably with a set of three cast-iron stove panels, of scriptural subjects, which were made around 1820 or 1830. There was also a pair of cast-iron gates taken from Foundry Yard, Hythe Hill, incorporating the inscription. "To the Smiths' Shop and Foundery." A visit to this part of the country leaves one with the impression that a little research would yield ample material for an account of the early history of the local ironfounding industry. Could the East Anglian Section of the Institute of British Foundrymen encourage one of its members to undertake the task?

"MARKSMAN."

Random Shots

The foundry is no great place for the student of ornithology, although "Marksman" seems to recall one shop in Scotland where swallows—or maybe starlings—have built their nests among the girders just under the roof. It has always been disappointing to him that our summer visitors, the sand martins, have not lived up to their name and made more use of our foundries. However, nature lovers will be glad that at long last birds have come into this week's news.

* * *

"Marksman" is indebted to Mr. A. J. While, of G. & R. Thomas, Limited, Hatherton Furnaces, Bloxwich, for the photograph reproduced below. The story attached to it, in Mr. While's own words, is this: "A few weeks ago a pair of wagtails built their nest in a stack of pig-iron close to the main railroad of our works, and notwithstanding the fact that our works' locomotive and steam travelling crane are constantly passing the spot, a cuckoo laid an egg in the nest. Shortly after hatching out, the

"IRON STARVATION" COULD NOT HAVE BEEN THE CAUSE OF THIS YOUNG CUCKOO'S DEJECTED EXPRESSION.

young cuckoo pushed the young wagtails out of their home and took full possession. In the course of a fortnight it became too large for the nest and used to perch in front of the nest on a piece of pig-iron as shown in the photograph, waiting for its foster mother to bring it food. It has since flown away or become a meal for the works' cat. We have noticed some suspicious-looking feathers near the weighbridge house!"

* * *

Although Mr. While does not actually say so, one presumes that it is now the turn of the wagtails to have full possession. If they behave as wagtails should, another brood may be expected in August, and "Marksman" hopes that no unwanted lodger will then intrude into the family circle. Life in a stack of pig-iron must be hard enough without that!

* * *

When in Colchester a few weeks back "Marksman" took the opportunity to slip into the museum there. Apart from the extensive collection of Roman remains—and the Romans, it is believed, were the cuckoos in the nest so far as King Cymbeline and his palace were concerned—there were two or three exhibits of interest to foundrymen. One was a cast-iron fireback, bearing the arms of Edward VI and dating back to about 1550. In the matter of execution "Marksman" thought this compared

(*Continued in previous column.*)

Copper in Cast Iron*

By A. J. NICOL SMITH, B.Sc.

Introduction

This Paper records the results of experimental work which was carried out at the British Cast Iron Research Association on the influence of copper in cast iron. The author wishes to express his thanks to the Council of the Association for permission to present the Paper and to his colleagues on the staff for their assistance in the work recorded.

When this investigation was initiated, the literature on the subject was in a very confused and contradictory condition. Thus, for example, Lipin[1] claimed that copper up to 7 per cent. increased the fluidity of cast iron, while Hamasumi[3] concluded that copper was without effect. The addition of copper was said by Lipin and Boegehold[2] to increase chill; Spencer and Walding,[4] Söhnchen and Piwowarsky,[5] Stead[6] and Hamasumi found no influence of copper on this property; Smalley,[7] Donaldson,[8] Rolfe,[9] Pfannenschmidt,[10] Hurst,[11] Hotan,[12] Long and Maclaren[13] decided that copper acted as a graphitising agent, while Taniguchi[14] decided that the depth of chill in iron rolls decreased up to 4 per cent. copper, but increased with copper beyond that percentage. Similar contradictions are evident in the work on the solubility of copper and in other properties, such as wear resistance. It was generally agreed, however, that additions of copper increased the hardness and strength and the corrosion-resistance of cast iron. Gregg and Daniloff[15] had recently summarised and correlated most of the available information on the subject, and while in some connections the position was clarified, yet in others the conflicting nature of the published information was emphasised.

It was thought that most of the confusion in the literature arose because most investigators had experimented with only a limited copper addition and often only on one base iron. It was decided that this investigation should first deal with the addition of relatively widely-spaced additions of copper to a series of base irons covering a wide range of composition, previous experience having shown the difficulties of drawing accurate metallurgical conclusions from experiments on a limited range of compositions. The first part of this report therefore deals with the preliminary investigation. This is followed by a second part which deals in greater detail with the influence of smaller quantities of copper on a more limited range of base materials, covering approximately the engineering irons of the present day.

Manufacture of Irons

The irons used in the preliminary investigation were made from Swedish white iron or hematite with additions of steel, ferro-alloys, nickel "F" shot, etc. In each case a 50-lb. charge was melted in a natural-draft coke-fired crucible furnace. After a set of bars had been cast, copper was added to the melt and stirred in. The crucible was then reheated for a short period and a second set of bars cast. More copper was added and the procedure was repeated. By this method five sets of varying copper content were obtained from each charge. The set of bars consisted of one bar each of 1.2 in., 0.875 in., 0.6 in. and 0.4 in. diameter, each 16 in. long. The bars were moulded in green sand, two to each box, and were cast at an angle between 20 deg. and 30 deg. to the vertical. Electrolytic copper in lumps of approximately two ounces weight was used for the copper additions.

* Paper read at the Annual Conference of the Institute of British Foundrymen in Bradford. Communication from the British Cast Iron Research Association.

The Alloying of Copper

Copper is a metal less readily oxidised than iron and melting at 1,083 deg. C. It is of greater density than iron. There is a negligible loss by oxidation on adding copper to cast iron, and reasonably large ladle additions, *e.g.*, up to 3 per cent. of copper, are possible. Provided that the melt is properly stirred to prevent segregation of liquid copper as a bottom layer, there is no difficulty in the alloying of copper.

MR. A. J. NICOL SMITH.

TABLE I.—*Composition of Experimental Bars.*

Bar no.	Analysis. Per cent. 1.2-in. bars.						
	T.C.	G.C.	C.C.	Si.	Mn.		Cu.
A210	3.69	0.04	3.65	0.37	0.42	—	Nil
A211	3.43	1.39	2.04	—	—	—	1.76
A212	3.33	2.18	1.15	—	—	—	3.31
A213	3.25	2.11	1.14	—	—	—	4.61
A214	3.20	2.04	1.16	0.29	0.30	—	4.77
A215	3.20	0.04	3.16	0.27	0.41	—	Nil
A216	3.07	0.09	2.98	—	—	—	1.86
A217	2.84	1.58	1.26	—	—	—	3.50
A218	2.88	1.56	1.32	—	—	—	5.41
A219	2.85	0.16	2.69	0.23	0.32	—	7.42
A220	3.31	2.28	1.03	1.61	0.72	—	Nil
A221	3.33	2.34	0.99	—	—	—	1.62
A222	3.19	2.21	0.98	—	—	—	3.43
A223	3.16	2.14	1.02	—	—	—	4.72
A224	3.21	2.37	0.84	1.41	0.62	—	5.47
A225	3.07	1.57	1.50	1.32	0.70	—	Nil
A226	3.93	1.90	1.03	—	—	—	1.79
A227	2.88	1.81	1.07	—	—	—	3.55
A228	2.82	1.70	1.12	—	—	—	5.63
A229	2.77	1.82	0.95	1.13	0.56	—	8.85
A230	3.21	2.39	0.82	2.38	0.61	—	Nil
A231	3.12	2.28	0.84	—	—	—	1.25
A232	3.10	2.24	0.86	—	—	—	3.07
A233	3.02	2.28	0.74	—	—	—	5.41
A234	2.93	2.29	0.64	2.08	0.63	—	5.79
A235	3.21	2.37	0.84	2.79	0.78	—	Nil
A236	2.57	1.79	0.78	2.14	—	—	1.70
A237	2.47	1.65	0.82	—	—	—	3.74
A238	2.24	1.59	0.65	—	—	—	8.19
A239	2.15	1.63	0.52	1.75	0.57	—	12.13
A240	3.7	—	—	0.4	0.4	1.5 Ni	Nil
A241	—	—	—	—	—	—	1.75
A242	—	—	—	—	—	—	3.50
A243	—	—	—	—	—	—	5.25
A244	3.4	—	—	0.3	0.3	1.5 Ni	7.00
A245	3.25	—	—	0.30	0.4	1.5 Ni	Nil
A246	—	—	—	—	—	—	2.0
A247	—	—	—	—	—	—	4.0
A248	—	—	—	—	—	—	6.0
A249	3.0	—	—	0.25	0.3	1.5 Ni	8.0

TABLE .—*continued.*

Bar no.	Analysis. Per cent. 1.2-in. bars.						
	T.C.	G.C.	C.C.	Si.	Mn.		Cu.
A250	3.54	0.89	2.65	1.18	1.32	—	Nil
A251	3.47	2.23	1.24	—	—	—	1.79
A252	3.42	2.24	1.18	—	—	—	3.39
A253	3.11	2.23	0.88	—	—	—	4.99
A254	3.36	2.37	0.99	1.07	1.25	—	6.85
A255	3.13	0.25	2.88	1.32	1.63	—	Nil
A256	3.10	1.72	1.38	—	—	—	1.50
A257	2.95	1.80	1.15	—	—	—	2.72
A258	3.04	1.85	1.19	—	—	—	4.13
A259	2.76	1.75	1.01	1.12	1.37	—	8.48
A260	3.34	2.33	1.01	2.25	2.22	—	Nil
A261	3.26	2.28	0.98	—	—	—	1.15
A262	3.16	2.17	0.99	—	—	—	3.90
A263	3.16	2.05	1.11	—	—	—	4.58
A264	3.01	2.06	0.95	1.98	1.91	—	8.19
A265	2.83	1.86	0.97	2.17	1.98	—	Nil
A266	2.80	1.78	1.02	—	—	—	1.92
A267	2.79	1.68	1.11	—	—	—	4.06
A268	2.67	1.55	1.12	—	—	—	5.46
A269	2.57	1.46	1.11	1.94	1.82	—	7.02
A270	3.30	2.48	0.82	2.25	0.71	0.45 Cr	Nil
A271	3.21	2.49	0.72	—	—	—	1.92
A272	3.13	2.31	0.82	—	—	—	3.61
A273	3.07	2.35	0.72	—	—	—	5.28
A274	2.97	2.37	0.60	2.00	0.63	0.43 Cr	7.68
A275	2.79	1.91	0.88	2.50	0.79	0.54 Cr	Nil
A276	2.75	2.08	0.67	—	—	—	1.95
A277	2.66	1.92	0.74	—	—	—	3.68
A278	2.56	1.77	0.79	—	—	—	5.89
A279	2.60	1.78	0.82	2.23	0.58	0.44 Cr	7.14
A300	3.4	—	—	1.2	0.7	0.7 Mo	Nil
A301	—	—	—	—	—	—	1.75
A302	—	—	—	—	—	—	3.50
A303	—	—	—	—	—	—	5.25
A304	3.25	—	—	1.1	0.6	0.65 Mo	7.0
A305	3.1	—	—	1.3	0.7	0.7 Mo	Nil
A306	—	—	—	—	—	—	2·0
A307	—	—	—	—	—	—	4.0
A308	—	—	—	—	—	—	6.0
A309	2.8	—	—	1.1	0.5	0.65 Mo	8.0

Analysis of Bars

The analyses of irons made in this preliminary investigation are shown in Table I. The heavy drop in total carbon and in silicon shown in series A235 to A239 was due to improper melting. The steel of the charge was not dissolved in the melt when the earlier bars were cast. The results given for the irons of series A240-244, A245-249, A300-304 and A305-309, are estimated analyses, while all other results are actual analyses.

Influence of Copper on Chill

The fractures of the test-bars, which from their variation in size constitute a sensitive chill test, show that the early additions of copper tend to graphitise the iron and to break down cementite. This action continues up to a copper content of about 3.5 per cent. With additions of copper in excess of this value, there is a reversal of the behaviour of copper and the chill increases as the copper content rises. This is well shown in Fig. 1, which shows the fracture of the series of bars A225-A229.

This effect of reversal of chill may be due directly to the copper or it may be an indirect effect due to reheating or some other cause, or it may be due to a diluting effect of copper present in excess of the solubility limit. To throw light on this question, some small melts were made and cast into dry-sand wedges. The charges used and the depths of chill obtained were:—

(1) Hematite + 15% steel + 0% Cu – $\frac{11}{32}$ in. chill.

(2) Hematite + 12% steel + 3% Cu – $\frac{3}{32}$ in chill.

(3) Hematite + 7% steel + 8% Cu – $\frac{3}{32}$ in. chill.

This inverse variation of steel content with copper content was designed to keep the dilution of the hematite constant and under these conditions the chill has remained unaltered from 3 to

8 per cent. of copper. Evidence will later be brought forward that under normal casting conditions, copper dissolves up to a limit of 3.5 per cent. It seems reasonable to assume, therefore, that up to this percentage copper acts as a graphitising agent, while the reversal of chill beyond this percentage is an indirect effect due probably to dilution.

Effect of Copper on Graphite Size and Formation

The graphite size, as seen from the microstructure and from the fractures of the test-bars, is refined by additions of copper. In many cases where copper is present above the liquid solubility limit, *i.e.*, where there are globules of primary copper present in the microstructure, the graphite is found to be refined completely and is present as supercooled graphite. The probable explanation of this is that the globules of copper present collect and coat the slag particles in the melt, thus promoting supercooling.

It must be emphasised that the figure of 3.5 per cent. given for the solubility of copper in cast iron refers to the amount which remains dissolved under ordinary casting conditions and not to the solid solubility under equilibrium conditions. The latter is probably much lower.

Influence of Copper on the Structure of Cast Iron

The introduction of copper into cast iron produces no marked changes in the microstructure. There is a refining action on the pearlite, a slight refining action on the graphite and in the lower carbon irons, a tendency to the formation of well-marked dendrites. By its graphitising effect, copper additions remove from the microstructure any free carbides that may be present, though copper does not tend to decompose pearlite.

No new constituent is introduced into the microstructure until the solubility limit is exceeded, when free copper appears. The free copper, which contains silicon, iron and possibly other elements in solution, occurs in two forms. What has been termed primary copper occurs in globules which are readily visible with the naked eye on the fracture or on a polished or machined section. These particles of copper are spheroidal in form and are entrapped as liquid copper when the melt solidifies. They are found on microexamination nearly always to contain a dove-grey inclusion which is probably manganese sulphide. Primary copper begins to appear in the structure of grey cast iron at a copper content of from 5 to 5.5 per cent., which may therefore be taken as the liquid solubility under normal conditions of casting.

There is also another form of free copper which may be termed secondary copper. This form occurs in particles which vary in size, but may be classed as microscopic. These particles begin to appear in the microstructure at a copper content of about 3.5 per cent. The exact figure is difficult to determine, since at reasonable magnifications the secondary copper is visible only as small black dots. Its first appearance is therefore not readily detected. In irons with a ferritic matrix, this copper is easily rendered visible by ordinary etching reagents. It was found, however, to be much more difficult to see in pearlitic irons, since most reagents brought out the pearlitic structure readily and thus disguised the copper particles. It was found, however, that a weak solution of iodine in alcohol (1 per cent. solution) was capable of revealing the copper without etching the pearlite. With this reagent the copper assumes the form of small dark dots visible at magnifications of 500 × to 1,000 ×. At high magnifications in the region of 1,500 × to 2,000 × it is possible to see the colour of copper in the particles.

The secondary copper begins to appear at a content of 3.5 per cent. and increases in amount until primary copper appears, after which the amount of secondary copper remains constant. It was thought that by quenching irons containing secondary copper from various temperatures, it would be possible to determine at what stage during the cooling the particles separated. It was found necessary to use a temperature of 1,100 deg. C. to effect the solution of the copper, and this indicates that on cooling the separation must be complete just below the solidus point of cast iron.

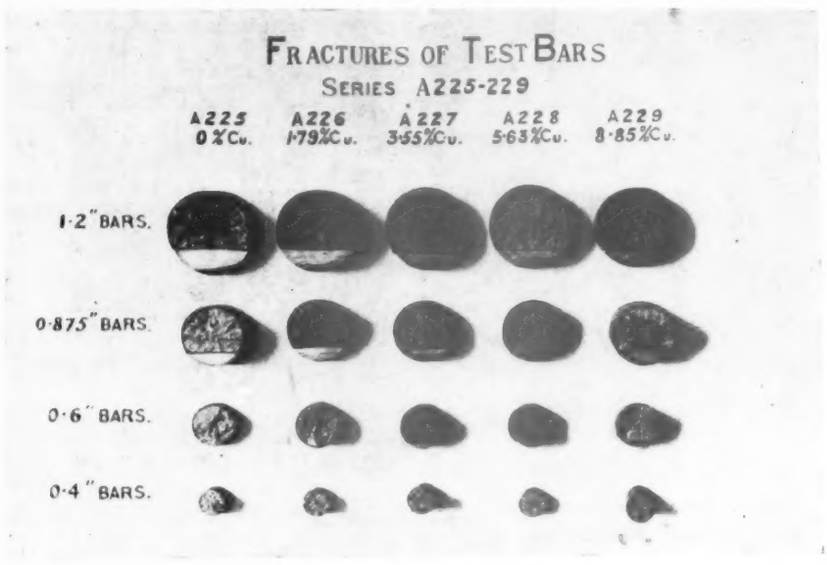

FIG. 1.

Solubility of Copper

It was decided not to attempt to determine the equilibrium solid solubility of copper in cast iron, since the system is known to be very sluggish, which would make the determination difficult and since a knowledge of this figure would not be expected greatly to affect practical application. It was soon noticed, however, that there is what might be termed a "practical solubility," that is, a limiting amount of copper which can be added to cast iron without producing the characteristics of a duplex alloy.

Evidence, which will be detailed later, obtained from the Brinell hardness, the chill, microscopic examination, thermal analysis and heat-treatment results, combined to show that this limit of solubility of copper is at about 3.5 per cent. The value is little affected by rate of cooling, *i.e.*, by the section of the casting, nor is it changed noticeably by variations in the composition of the base iron, with the exception that in the presence of nickel, copper is somewhat more soluble. The influence of nickel is marked. The Mond Nickel Company's work indicates that the addition of every 1 per cent. of nickel increases the solubility of copper by 0.5 per cent. The figure of 3.5 per cent. copper given above refers to an iron free from nickel.

Heat-treatment tests with specimens of copper cast iron show that it is extremely difficult to precipitate copper from solution and equally difficult to persuade free copper present in the cast condition to enter into solution. The solution of copper is unlikely to be altered by any ordinary heat-treatment.

Effect of Copper on Mechanical Properties

Transverse Strength.—The test-bars were broken in transverse on 14-in. centres after most of the adhering sand had been removed and any flashing ground off. The transverse results are given in Table II, where the strengths have been converted to moduli of rupture in tons per sq. in., and the deflections are given in inches on the 14-in. span.

TABLE II.—*Moduli of Rupture and Deflections in Transverse.*

No.	1.2-in. bars.		0.875-in. bars.	
	Strength. Tons per sq. in.	Deflection. Inches on 14 in.	Strength. Tons per sq. in.	Deflection. Inches on 14 in.
A210 ..	23*	0.07	27*	0.09
A211 ..	25*	0.08	21*F	0.07
A212 ..	26	0.12	30*	0.11
A213 ..	25	0.12	24*	0.09
A214 ..	21	0.10	25*	0.10
A215 ..	30*	0.07	31*F	0.08
A216 ..	28*	0.08	29*F	0.10
A217 ..	23*F	0.09	23*F	0.09
A218 ..	25*F	0.11	31*	0.13
A219 ..	27*F	0.10	26*F	0.10
A220 ..	23	0.15	25	0.20
A221 ..	28	0.12	27	0.15
A222 ..	26	0.15	30	0.18
A223 ..	21	0.09	24	0.13
A224 ..	25	0.08	27	0.12
A225 ..	33*	0.09	24*	0.07
A226 ..	27	0.10	31*	0.12
A227 ..	21F	0.09	24F	0.12
A228 ..	23	0.09	25	0.09
A229 ..	18F*f*	0.06	32**f*	0.12
A230 ..	25	0.13	27	0.15
A231 ..	26	0.13	26	0.13
A232 ..	26	0.13	28	0.17
A233 ..	24	0.11	29	0.11
A234 ..	26*f*	0.08	23*f*	0.11
A235 ..	27	0.17	27	0.19
A236 ..	25	0.06	27	0.11
A237 ..	26	0.10	—	—
A238 ..	26*f*	0.09	29*	0.12
A239 ..	25*f*	0.08	—**f*	—
A240 ..	24*	0.06	21*F	0.07
A241 ..	24	0.08	30*	0.14
A242 ..	25	0.11	26	0.13
A243 ..	29	0.14	28	0.12
A244 ..	29F	0.14	28	0.16
A245 ..	31*	0.06	35*F	0.11
A246 ..	25*	0.06	35*	0.09
A247 ..	26	0.08	33*F	0.12
A248 ..	24	0.09	24*	0.10
A249 ..	—*f*	—	20*F	0.11
A250 ..	26*	0.07	24*	0.08
A251 ..	28	0.13	30*	0.14
A252 ..	27	0.14	30	0.16
A253 ..	25	0.11	30	0.11
A254 ..	31*f*	0.12	33**f*	0.12
A255 ..	27*	0.04	26*F	0.05
A256 ..	30*	0.11	32*	0.11
A257 ..	29	0.12	30	0.11
A258 ..	26F	0.12	25F	0.10
A259 ..	30*f*	0.10	39*	0.15

TABLE II.—*continued.*

No.	1.2-in. bars. Strength. Tons per sq. in.	1.2-in. bars. Deflection. Inches on 14 in.	0.875-in. bars. Strength. Tons per sq. in.	0.875-in. bars. Deflection. Inches on 14 in.
A260 ..	29	0.14	33	0.17
A261 ..	29	0.14	29	0.16
A262 ..	26	0.12	29	0.15
A263 ..	28	0.10	30F	0.18
A264 ..	30*f*	0.11	39*F	0.16
A265 ..	30	0.10	32	0.14
A266 ..	28	0.11	34	0.15
A267 ..	29	0.11	33	0.11
A268 ..	26	0.10	31	0.13
A269 ..	30	0.11	36*	0.10
A270 ..	25	0.12	32	0.17
A271 ..	27	0.13	32	0.17
A272 ..	27	0.13	31	0.12
A273 ..	23	0.10	31	0.15
A274 ..	26*f*	0.10	38*f*	0.15
A275 ..	29	0.11	35*	0.14
A276 ..	30	0.11	32	0.11
A277 ..	29	0.10	31	0.09
A278 ..	27	0.10	29	0.08
A279 ..	24	0.08	33*	0.12
A300 ..	26*	0.07	31*	0.08
A301 ..	33	0.15	34	0.23
A302 ..	33	0.18	34	0.23
A303 ..	32	0.16	33	0.17
A304 ..	28*f*	0.13	22**f*	0.10
A305 ..	32	0.16	36*	0.17
A306 ..	35*	0.10	39*	0.09
A307 ..	35*	0.11	36*	0.08
A308 ..	26*	0.06	36*	0.11
A309 ..	37*F	0.12	46*F	0.16

* Indicates that the fracture of the bar is either white or mottled.

F Indicates that there is a flaw in the fracture.

f Indicates that there is free copper visible in the fracture.

The results show that copper has not a great influence on the transverse strength of grey cast iron. Its general tendency, however, is to give rise to an increase in this value with the first addition of copper, that is, in quantities of 2 per cent. or less. The strength tends to decrease with the appearance of free copper though the decrease is not so marked as entirely to prohibit the use of these materials. The influence of copper on the deflection in transverse seems somewhat random, although a decrease in deflection values occurs when free copper appears.

TABLE III.—*Tensile Test Results.*

(Specimens machined from the broken halves of the 1.2-in. bars.)

Specimen no.	Breaking load. Tons.	Diameter. In.	Breaking load. Tons per sq. in.	Transverse strength. Tons per sq. in.
A212	8.50	0.812	16.40	26
A221	7.55	0.798	15.10	28
A228	9.30	0.798	18.60	23
A229	7.40	0.798	14.80*f*	18F*f*
A232	6.90	0.798	13.80	26
A237	3.80	0.798	7.60F	26F
A243	9.95	0.798	19.90	29
A252	7.61	0.792	15.40	27
A257	9.07	0.798	18.14	29
A259	7.50	0.798	15.00*f*	30*f*
A261	8.96	0.798	17.92	29
A267	8.43	0.794	17.50	29
A272	7.60	0.798	15.20	27
A276	9.23	0.798	18.46	30

F Indicates that there was a flaw in the fracture.

f Indicates that there was free copper visible in the fracture.

The last column gives the transverse rupture stress on the bar from which the tensile specimen was machined.

Only a few tensile tests were carried out on these irons, in each case from a specimen machined from the 1.2 in. bars after breaking in transverse. The results are given in Table III, and they are insufficient to enable any conclusions to be drawn concerning the effect of copper on the tensile strength.

Influence of Copper on the Hardness of Cast Iron

Copper is a graphitising element and tends to break down any free cementite present in cast iron. It does not have any marked graphitising action on the carbide of pearlite and in this respect it resembles nickel. The addition of copper to irons containing free cementite results in the softening of the iron owing to the decomposition of this constituent. That is to say, white or mottled irons are turned grey and therefore become softer. The addition of copper to ordinary cementite-free grey cast iron, on the other hand, results in an increase in hardness. This is due to the solution of copper in the matrix. It is well known that increased hardness of this type does not give rise to appreciably greater difficulty in machining as does increased hardness of the type due to the presence of carbide or other hard constituent.

The hardness test results were taken with a 10-mm. ball and 3,000-kg. load, on flats ground on the sides of the 1.2-in. diameter bars alongside the transverse fracture and also on the centre of a section of these bars where machinability permitted. The results are shown in Table IV.

The hardness increases with the copper content up to a value of about 3.5 per cent. copper. The addition of copper beyond this percentage has very little effect. It actually causes a slight softening due to the appearance of a softer constituent, free copper. It will be seen that in general the influence of copper on hardness of cementite-free grey cast iron could be represented by a graph of the type shown in Fig. 2. This break in the hardness curve at 3.5 per cent. copper is part of the evidence that it is at this figure that the solubility limit is exceeded and free copper first appears.

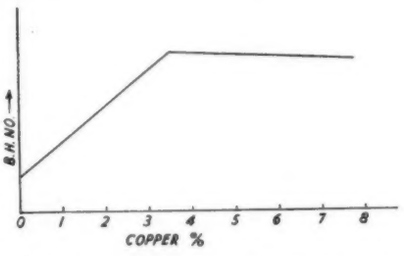

FIG. 2.—INFLUENCE OF COPPER ON THE BRINELL HARDNESS OF CAST IRON.

The difference in hardness between the centre and the edge of the bars does not decrease markedly with rise of copper content. Thus, although copper has the effect of equalising the hardness of thick and thin sections of a casting by graphitising thin portions and hardening the matrix of thick ones, yet it has only a small influence in equalising the hardness throughout thick sections.

Influence of Copper on Resistance to Impact

Several of the irons made in this investigation have been subjected to a repeated impact test. The test is a modified form of the Stanton test. It was carried out on the halves of the 0.875 in. bars after they had been broken in transverse. The results of the test, given in Table V, show that copper present in moderate quantities of the order of 2 per cent. has a favourable influence on the toughness of grey cast iron. The test does not always give results that can be duplicated, but this is to be expected from the nature of the test, since it lies between a fatigue test and a true impact test.

The two sets of bars, A235-237 and A265-267, which show a decrease in impact value with the addition of copper, are both low total-carbon irons. Examination of their microstructure has revealed that the graphite exists in mixed areas of supercooled and flake graphite. It has been shown by Norbury and Morgan[16] that a mixture of supercooled and flake graphite in low total carbon irons gives rise to low and erratic impact values. It has not been determined whether the formation of patches of supercooled graphite in low total carbon irons is a characteristic of copper additions; whether it is due to reheat-

TABLE IV.—*Brinell Hardness Test Results* (30/10/3,000).

The 1.2-in. bars were tested on flats ground on the sides and on the centre of a cross section where the bars could be sawn.

Specimen.	A210	A211	A212	A213	A214
Hardness—					
Side ..	435*	356*	250	263	223
Centre ..	—	—	256	263	255
Specimen.	A215	A216	A217	A218	A219
Hardness—					
Side ..	388*	415*	380*	337*	406*
Centre ..	—	—	—	—	—
Specimen.	A220	A221	A222	A223	A224
Hardness—					
Side ..	200	239	234	255	248
Centre ..	167	190	215	211	215
Specimen.	A225	A226	A227	A228	A229
Hardness—					
Side ..	295*	246	275	283	268
Centre ..	—	226	272	268	252
Specimen.	A230	A231	A232	A233	A234
Hardness—					
Side ..	188	224	237	255	256
Centre ..	173	202	212	229	229
Specimen.	A235	A236	A237	A238	A239
Hardness—					
Side ..	197	225	293	283	272
Centre ..	167	235	280	282	256
Specimen.	A240	A241	A242	A243	A244
Hardness—					
Side ..	448*	208	240	256	257
Centre ..	—	186	223	239	241
Specimen.	A245	A246	A247	A248	A249
Hardness—					
Side ..	444*	467*	325	321	315
Centre ..	—	—	295	311	319
Specimen.	A250	A251	A252	A253	A254
Hardness—					
Side ..	429*	231	271	280	275
Centre ..	—	230	240	256	255
Specimen.	A255	A256	A257	A258	A259
Hardness—					
Side ..	368*	235*	297	286	319
Centre ..	—	—	285	263	283
Specimen.	A260	A261	A262	A263	A264
Hardness—					
Side ..	246	253	283	283	293
Centre ..	217	229	257	249	269
Specimen.	A265	A266	A267	A268	A269
Hardness—					
Side ..	259	285	315	309	315
Centre ..	245	250	298	300	302
Specimen.	A270	A271	A272	A273	A274
Hardness—					
Side ..	214	240	255	260	266
Centre ..	193	224	229	237	241
Specimen.	A275	A276	A277	A278	A279
Hardness—					
Side ..	249	268	295	280	274
Centre ..	228	268	277	269	269
Specimen.	A300	A301	A302	A303	A304
Hardness—					
Side ..	309*	266	302	385	313
Centre ..	—	253	—	—	—
Specimen.	A305	A306	A307	A308	A309
Hardness—					
Side ..	240	406*	441*	412*	319*
Centre ..	219	—	—	—	—

* Mottled or white fracture.

ing of the melt, or whether, as is probable, at any rate in the case of the series A235-237, it is due to steel dissolving in the melt during manufacture. Even should this prove to be due directly to the copper addition, it is unlikely to prove a serious handicap to the use of copper, as it apparently occurs only when the total carbon content has been lowered to the neighbourhood of 2.5 per cent.

It will be noticed that the considerable influence of copper on the impact value is enhanced by the simultaneous presence of chromium or of high manganese.

The mechanical results show in general that while copper additions cause an improvement in the quality of cast iron, particularly in the toughness, yet the best results are obtained by the substitution of copper for silicon or by the simultaneous presence of copper and chromium or of copper with a high manganese content. It is possible to estimate from a study of the test-bar fractures that the graphitising effect of copper is about equivalent to that of one-third of the quantity of silicon. This means that the chilling effect caused by reducing the silicon content by 0.5 per cent. could be counterbalanced by adding 1.5 per cent. of copper. It may therefore be estimated that simultaneous addition of 1.0 per cent. copper, together with 1.4 per cent. manganese or with 0.3 per cent. chromium should not affect the chill properties of an iron.

TABLE V.—*Repeated Impact Tests.*

(Specimens machined from the halves of the 0.875-in. bars.)

Specimen ..	A220	A221	A222	A228	—
Blows ..	562	758	416	191	—
	415	678	540	—	—
Specimen ..	A230	A231	A232	A233	A234
Blows ..	327	518	725	267	230
Specimen ..	A235	A236	A237	—	—
Blows ..	384	365	—	—	—
	452	259	63	—	—
Specimen ..	—	—	A252	—	—
Blows ..	—	—	300	—	—
Specimen ..	—	—	A257	—	—
Blows ..	—	—	520	—	—
Specimen ..	A260	A261	A262	—	—
Blows ..	950	651	340	—	—
	548	1722	153	—	—
Specimen ..	A265	A266	A267	—	—
Blows ..	338	313	274	—	—
Specimen ..	A270	A271	A272	—	—
Blows ..	695	758	946	—	—
Specimen ..	—	A276	—	—	—
Blows ..	—	1043	—	—	—
Specimen ..	—	A301	—	—	—
Blows ..	—	5780*	—	—	—

* Indicates that the specimen was taken from the 1.2-in. bar.

TABLE VI.—*Influence of Heat-Treatment on the Hardness.*

(Hardness tests were taken with a 5-mm. ball and a 750-kg. load. In each case the figure given is the mean value for two or three tests.)

A.—Prolonged Treatment at 450 deg. C.

(Specimens air-cooled after each successive treatment.)

Treatment ..	A235	A236	A237	A238	A239
As-cast	172	239	264	280	269
After 30 min. at 450 deg. C. ..	165	242	279	276	264
After 1 hr. at 450 deg. C.	175	247	266	280	271
After 2 hrs. at 450 deg. C. ..	176	249	275	284	263
After 4 hrs. at 450 deg. C. ..	179	244	269	275	262

B.—Successive Treatments at Increasing Temperatures.

(Specimens air-cooled after each successive treatment.)

Treatment ..	A235	A236	A237	A238	A239
As cast	174	233	261	277	268
After 1 hr. at 400 deg. C.	162	236	262	276	263
After 1 hr. at 500 deg. C.	186	267	263	269	270
After 1 hr. at 600 deg. C.	168	256	255	263	251

Precipitation Hardening of Grey Cast Iron Containing Copper

Heat-treatment tests have been carried out on the irons of the series A235-239 with the object of inducing precipitation hardening. The influence on the hardness of prolonged heat-treatment at 450 deg. C. and of successive treatments of one hour each at rising temperatures is shown in Table VI.

The results indicate that in iron A236 with 1.70 per cent. copper, an increase of about 30 points in hardness is obtained. This is far less than is possible with the copper-containing mild steels and would not normally warrant the expense of the treatment.

To check the possible effect of a solution treatment prior to the precipitation treatment and of a longer time at higher precipitation temperature, it was decided to carry out further tests on A236:—

Treatment.	Brinell hardness number.	Average.
As cast	263, 262, 262, 260, 252, 262, 256	260
Tempered 4 hrs. at 530 deg. C.	268, 260, 257, 255, 252	258
Normalised 1 hr. at 850 deg. C.	236, 246, 241	241
Normalised and tempered as above ..	257, 260, 263	260

These tests were taken with a 10 mm. ball and 3,000 kg. load. The difference in hardness between the as-cast specimen and the figures for the similar state in Table VI are due to the fact that the specimens, through shortage of material, were taken from close to the ends of the bars. It will be seen that there is no increase in hardness following the tempering of the as-cast material, while the precipitation hardening of about 20 points Brinell following the solution treatment is just sufficient to compensate for the inevitable drop in combined carbon which occurs during the solution treatment.

It is concluded that the precipitation hardening possible in copper-containing pearlitic grey cast iron is insufficient to be of practical use.

Malleablising of Copper Cast Iron

Although no attempt has been made to investigate the effect of copper on malleable iron, yet it was thought worth while to attempt to determine the influence of copper on the breakdown of primary carbide during annealing. Accordingly the 0.4 in. bars of series A210-214 and A215-219 were heated in an electric tube furnace for a period of seven hours at a temperature of 900 deg. C. After cooling in the furnace the fractures of the bars were as follow:—

A210	White	A215	White.
A211	White	A216	Mottled (20 per cent. white).
A212	Black	A217	Black.
A213	White	A218	Mottled (10 per cent. white).
A214	White	A219	White.

This indicates that copper in small quantities accelerates the annealing of blackheart malleable and that the maximum effect is obtained in the region of 3.5 per cent. copper.

Dilatometer Tests on Copper-Containing Cast Irons

Dilatometer tests were taken with a Chevenard thermal analyser on specimens machined from the broken halves of the repeated impact specimens of the irons A230-A234. In all cases there is a large expansion at the *Ar* point, owing to graphitisation. This results in a permanent expansion of the specimen. Table VII gives the critical points and the values of these permanent expansions.

TABLE VII.—*Critical Points and Values of Permanent Expansion of Copper Cast Irons.*

Specimen no.	Cu Per cent.	Ac point heating. Deg. C.	Ar point cooling. Deg. C.	Permanent expansion. Per cent.
A230	Nil	785	685	0.280
A231	1.25	785	665	0.355
A232	3.07	775–785	670–660	0.395
A233	5.41	795–830	715–705	0.330
A234	5.79	830–890	735–700	0.230

A230 shows definite periods of stationary temperature at the critical points, and this is the case with A231. The other irons, however, show the critical points occurring over a range of temperatures. In the first specimen there is a contraction at the Ac point. With A231 there is merely a halt in the expansion. A232 continues to expand through the critical range, though the rate of expansion is less at this point. Specimen A233 gives a halt of the same type as in A231, while A234 resembles A230 in showing the usual contraction. The graphitising influence of copper as seen from the permanent expansion figures is in good agreement with that shown by the malleablising tests.

Electrical Resistance of Grey Cast Iron Containing Copper

The electrical resistance of several sets of bars was determined on the repeated impact pieces before the notches were cut. The results were not sufficient to enable any break at the solubility limit to be detected, but the general conclusion was reached that the addition of copper lowers the resistivity of cast iron.

(To be continued.)

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Industrial Eye Injuries

Opening an exhibition dealing with the prevention of industrial eye injuries at the Royal Eye Hospital, London, on June 22, the Earl of Athlone said he was convinced that the work of propaganda and education which was proposed to be carried out by the Industrial Eye Injuries Committee of the Royal Eye Hospital must eventually prove of incalculable value not only to industry in South London, but throughout the whole country. The Exhibition should have constructive results in preventing serious injury to the eyes of work-people and in many cases preventing ultimate blindness.

Centenary of George Kent, Limited

There are few industrial undertakings which have a better claim to the line "Still achieving, still pursuing" than George Kent, Limited, who celebrate their centenary this year.

It is certainly unusual, if, indeed, not unique, that the control of the concern throughout the full period of 100 years has been in the hands of only two people, the late George Kent, the founder, and his son, Sir Walter Kent, C.B.E., the present chairman and managing director. After serving his apprenticeship to an ironmonger, George Kent commenced business on his own account as a manufacturer of venetian blinds; that, however, was very definitely not his forte; he was an inventive genius, and in the early days devoted himself to the perfecting of domestic labour-saving devices.

The foundations of the present company were laid in 1838, when George Kent commenced to manufacture what one may call mechanical devices. He it was who patented the rotary knife-cleaning machine, and for the sale of this and other of his specialities he opened premises in the Strand, London. He combined with his inventive ability a progressive opportunism, truly a somewhat unusual combination.

In 1867 George Kent was joined by J. W. Sutton, and he it was who suggested the water meter, and from this suggestion grew the hydra-headed business of the present company. The company took up the agency for the Meinecke inferential meter, whilst later the world's patents were bought from Mr. Frank Walker of a meter working on a semi-rotary principle, actually the first "Uniform" meter. In 1893 the Venturi meter was added to the manufactures of the firm, and from then onwards to 1910 activities were almost exclusively confined to the measurement of the flow of water.

At the same time, the staff of the research department, in charge of the late John Laurence Hodgson, B.Sc., were devoting their attention to the consideration of adapting the Venturi principle for the measurement of air, the outcome being the introduction of the Kent Venturi meters. From this beginning, the measurement of many other gases, and also of steam, was successfully accomplished.

In brief, the main productions of the firm at the present date may be described as covering practically the whole range of instruments for the measurement and control of the flow of fluids. A very important and comparatively recent development is the automatic boiler-control equipment. For the control of pressure, a very delicate piece of mechanism was designed, which takes into consideration not only the deviation from the pressure to be maintained, but the rate of change of pressure, so that conditions are maintained within a limit of error of less than 1 per cent., however much or however suddenly the load may vary.

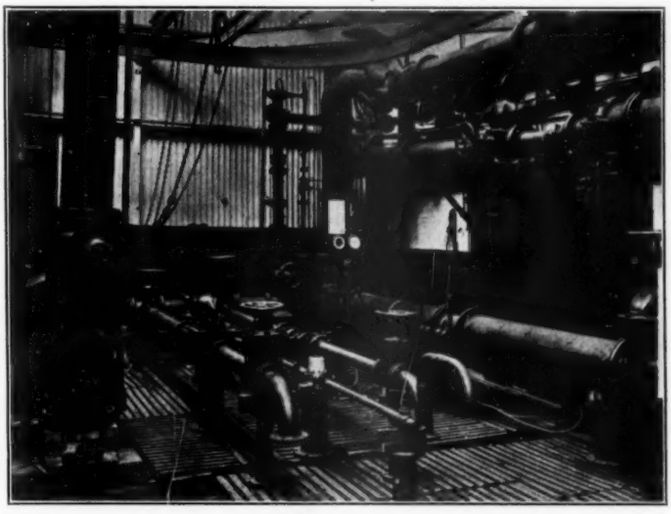
Obviously, to obtain such result, many factors called for consideration, such as forced draft, induced draft, rate of fuel supply, etc. All these are automatically controlled through the instrumentality of the master controller and sub-controllers, so arranged that either complete or partial control can be provided, as desired.

The firm was converted into a Limited Liability Company in 1907. The Luton Works occupies nearly 7 acres, and with a floor space of 280,000 sq. ft. is the largest works in Great Britain engaged in the manufacture of industrial instruments and controllers, and finds employment for 1,750 hands. Welfare, education and social activities are very practically considered. On the educational side, there are two schemes of apprenticeship, the junior for the training of craftsmen and recruits for junior technical services, the senior for the higher technical and administrative positions. Each

VIEW IN THE NON-FERROUS FOUNDRY.

VIEW IN ONE OF THE BAYS OF THE HEAVY MACHINE SHOP.

VIEW IN THE VENTURI METER AND INSTRUMENT SHOP.



VIEW IN THE HYDRAULIC TEST PLANT.

grade has its own technical school, staffed by the company's employees. So successful has this education scheme been that there is a continual flow of applications from clients for ex-apprentices. In addition to scientific societies, there is an athletic club, with a well-appointed sports ground.

Space does not permit of a lengthy description of the works; we must content ourselves with a few notes concerning the various shops, from which it will be seen that the manufactures of the company are strictly sectionalised, and for the most part are made on mass-production lines. In the tool room, amongst the usual assembly of tools is a special jig-borer, made by the Société Genevoise, and a Zeiss toolmaker's microscope and shadow projector. The heavy-machine shop is covered by four bays, and here, in addition to drilling, turning, milling and planing machines, are situated the tinsmith's, welding and forge shops.

The manufacture of the Bishop steering gear was taken up some six years ago, for which purpose shops have been laid out for quantity production, the present output being some 4,000 complete steering gear units per week. The Venturi meter and instrument shops cover a floor area of upwards of 10,000 sq. ft.

The heat-treatment shop, which has recently been rebuilt and entirely re-equipped, contains 11 furnaces of various types worked with the "Multelec" automatic temperature control. In this department are also housed the sand-blasting plant, washing plant, etc. Separate shops are laid off for the calibration of instruments. The several shops provide for the calibration of flow recorders operated on the differential pressure principle, including "K.M." meters, A, B and Q type Venturi recorders, T type steam meters, ring-balance recorders and combustion-efficiency meters. In this department every instrument is individually calibrated over the whole of its range, and is then subject to a final examination.

The equipment of the air-meter calibration department includes compressors, blowers and standard Board of Trade bell-testing apparatus. Installations of air and gas meters for flows up to 180,000 cub. ft. per hr. can be dealt with through pipes up to 24 in. dia.

A special concrete building with subterranean tanks houses the test shop for the calibration of mechanical oil and petrol meters. There are four main lines, and meters up to 6 in. in size are dealt with, representing flows up to 10,000 galls. per hour. Differential pressure-flow recorders may be either direct or remote reading, and in the department for the calibration of telerecorders facilities are provided for calibrating remote reading meters. Direct current can be generated up to 750 volts, alternating current, 3-phase, up to 400 volts, and single-phase up to 1,000 volts. This department is in direct contact with the instrument and panel-assembly shops, and is responsible for the carrying out of all "back of panel wiring."

The hydraulic-test plant includes equipment for the volumetric calibration from overhead tanks as well as circulating pumps through Venturi meters. Full-scale tests are made with flows up to 150,000 galls. per hr.

Three shops are laid off for testing mechanical water meters, their aggregate capacity being 1,500 meters per week. All meters are tested against calibrated tanks at all rates of flow, including, for the smaller sizes, a 12-hr. test at one gallon per hour.

Other departments include a foundry for the production of castings in brass, gunmetal and aluminium alloys, a well-equipped laboratory, drawing office and an exhibition room in which is displayed every standard type of instrument manufactured.

A MEETING of the ordinary shareholders of Newman Industries, Limited, has approved the revised capital proposals.

Plywood for Patternmaking

BY E. DRINKWATER.

Rarely even to-day is plywood used in patternshops, and although prejudice may have something to do with this its suitability for most purposes is doubted. On the other hand, plywood is so cheap to-day that there are purposes for which it is distinctly useful and for which it ought to be more generally used. For one-off jobs and when work is wanted in a hurry, plywood can often be used advantageously; even where a number of castings are wanted from a pattern, provided the work is painted and varnished to protect it from the damp sand, it is satisfactory. The very cheap grade of material is suitable for one-off jobs, but for better-class work the damp-proof plywood used for aircraft construction is more satisfactory.

It is sometimes possible to use plywood in making a cylinder barrel. The grounds or "bridges" are sandpapered to a diameter and then plywood bent round them and screwed. This is not nearly as good as building with staves, but it is very much cheaper and makes quite a good job. Where branches or bosses have to be fitted a difficulty presents itself but this can be overcome by fitting blocks inside the barrel and between the grounds to take screws.

Even if plywood is not employed for the main construction of a pattern, it has a distinct use when making brackets, etc. In corebox work it can be even more useful than in pattern construction. In "filling in" a big corebox, the fitting of staves is often quite a lengthy undertaking and it is not always satisfactory to use sweeps. Indeed, it is as a substitute for strickles that plywood is often most valuable. The little extra work in the patternshop may save a great deal of work in the foundry. It is not wise to use plywood when any fitting has to be done, because it is nearly impossible to cut it with a chisel or a gouge. It ought always to be cut to almost the exact size at the saw, although the edges can be trimmed with a sharp plane. The sandpapering machine where it can be used makes the best finish. Screws must always be used for holding it in position, and it is more important than for other work that a bit of the correct size should be used, with a countersink just sufficiently deep to take the head.

Substitute for Skeleton Work

As a substitute for skeleton patternmaking, plywood is usually satisfactory. A disadvantage is that the wood is not shaped but held under strain, and, if it is used for very small diameters, it may give trouble. On the other hand an important advantage is that the moulder or coremaker may have less work in finishing off surfaces, and often a better draw can be obtained. For one-off jobs or jobs that are wanted in a hurry, an awkward shape can sometimes be "generated" by plywood. For templates it is not very useful because of the difficulty of cutting it.

The use of plywood has serious limitations. Thick plywood is, in most cases, too expensive, and the thin type has to be well supported, or the moulder will alter it when ramming. Again, while an ordinary solid or skeleton pattern can be stored outside, and used in many cases years afterwards, the weather will soon ruin a plywood covering. In the case of a covered pattern store, however, there is no reason why damp-proof plywood, painted and varnished, should not have a permanent value.

International Ferro-Silicon Syndicate

Contrary to previous reports, it is now stated that the International Ferro-Silicon Syndicate has only been prolonged until September 30. A further decision in the matter is expected as a result of a meeting of the Syndicate to be held at the beginning of July

Czecho-Slovakian Foundrymen's Association

The 15th annual meeting of the Czecho-Slovakian Foundrymen's Association was held last month at Zlin, about 150 members participating. On the opening day, after an official welcome by the President, Prof. Pisek, who expressed his pleasure at the presence of delegates from Hungary and Jugo Slavia, the meeting was addressed by Mr. R. Uxa (chairman of the Zlin Branch); Mr. Zavrtálek (deputy Mayor); Mr. Hrádek (Principal of the technical school), and Mr. B. Sevcík (works manager of the Bata concern).

The rest of the morning was spent visiting the Bata works. The foundry has been entirely rebuilt and it now makes both heavy and light grey-iron castings as well as manufacturing all types of non-ferrous work, all of which is absorbed in the Bata works.

After luncheon, a visit was paid to the new works about 6 or 7 miles from Zlin, where there are spinning and weaving mills, tanneries, paper mills and a shoe-polish factory. Additionally, there is a shipyard for the construction of barges, for a canal, partly constructed, is to connect Zlin with the Danube.

At a committee meeting held during the evening it was decided to elect Prof. Portevin, of Paris, an honorary member of the Association. A gold medal was awarded to Prof. Hasa, of Prague; a silver medal to Mr. K. Petucha, of Vitkovice Ironworks, and a bronze medal to Mr. K. Macecek.

On the second day the members paid homage at the grave of Mr. Thomas Bata, and in the afternoon visits were paid to the public buildings in Zlin, a technical session being held later. After holding the annual general meeting, a banquet was held. The third day was taken up with an excursion, and on the final day visits were paid to the works at Trinec and Vitkovice at Moravska-Ostrava.

Catalogue Received

Drying Plants. We found this sectional catalogue from Keith Blackman, Limited, of 27, Farringdon Avenue, London, E.C.4, extremely interesting, because of the humidity table on page 135, which rationalises to some extent such problems as plain mould and core drying. We have said "to some extent," because of the qualifying statement, "In practice it is seldom found desirable to circulate air in a drying room until it is fully saturated. It is allowed to escape before it reaches this stage, the actual temperature and humidity depending chiefly upon the material to be dried." The question obviously arises whether the humidity and temperature could be worked out for such propositions as straight core drying or in connection with moving the moisture from enamel sprayed on to goods to be fused. Towards the end of this catalogue is an illustrated account of a low-pressure gas-fired mould and core drying oven.

Light Alloys by Specification

The Aluminium Information Bureau, of Bush House, Aldwych, London, W.C.2, has issued a table giving the mechanical properties, chemical composition and heat-treatment of about 14 aluminium sand and chill castings covered by current specifications. This table demonstrates in the clearest possible manner that modern light alloys can now be associated with tensile strengths up to 20 tons per sq. in., and not, as some engineers still fondly imagine, a matter of a mere ten. The table is of foolscap size and a particularly clear, though small, type has been used. It is available to our readers on request to the Aluminium Information Bureau.

Relief of Internal Stress in Castings

By L. E. BENSON, M.Sc., and H. ALLISON, B.Sc.(Tech.)

(*Concluded from page 528.*)

ADMIRALTY GUNMETAL AND HIGH-TENSILE BRONZE

It is not usual to anneal non-ferrous castings, but for some purposes where permanence of dimensions is important and where absence of internal stresses must be assured annealing may be desirable. To obtain some idea of the behaviour of such alloys, stress relief curves have been constructed for Admiralty gunmetal and a high-tensile bronze, these alloys being chosen deliberately as being important representatives of the Cu : Sn and Cu : Zn types of alloy.

To simulate conditions that would be likely to occur in actual castings, material for the tests was obtained as sand-cast slabs 9 in. by 9 in. by ¾ in. thick, these being machined into strips of the desired dimensions. Particulars of the materials are as follow, the test figures being obtained on pieces machined from sand-cast bars :—

Admiralty Gunmetal.—Cu, 88.0; Sn, 10.0; and Zn, 2.0 per cent.

H.-T. Bronze.—Cu, 55.93; Fe, 1.49; Mn, 3.74; and Zn, 35.03 per cent.

Admiralty Gunmetal.—Yield point, 9.7 tons per sq. in.; ultimate tensile strength, 17.4 tons per sq. in.; and elongation, 16.0 per cent.

H.-T. Bronze.—Yield point, 21.8 tons per sq. in.; ultimate tensile strength, 42.3 tons per sq. in.; and elongation, 28.0 per cent.

Particulars of the annealing experiments are given in Table IV, and the stress relief : temperature curves for an annealing period of 3 hrs. are shown plotted in Fig. 6.

The curves in Fig. 6 show that in these non-ferrous alloys the initial stresses are dissipated at a much lower temperature than with steel or cast iron, substantial freedom from stress being obtained after annealing at 400 deg. C. for high-tensile bronze and 500 deg. C. for gunmetal. The curves are also of a somewhat different form, the steepest part occurring at an earlier stage.

It is also important to note that although the copper-zinc alloy has a tensile strength in the cold more than twice as great as the copper-tin alloy, the temperature necessary to bring about an important degree of stress relief is approximately 100 deg. C. lower. Whilst such a result might not be expected, it is not altogether surprising since, as has been pointed out, stress relief is really a creep phenomenon and the study of creep has shown that the behaviour of materials under stress at atmospheric temperature can be altogether misleading as regards their behaviour under stress at elevated temperatures. Indeed, Dickenson in his pioneer Paper of 1922[2] gives data regarding a nickel-chrome steel which had a tensile strength in the cold of 52.8 tons per sq. in., as against 43.2 tons per sq. in. for a carbon steel, but which, nevertheless, broke in one-tenth the time for the latter steel when tested at 550 to 600 deg. C.

MR. H. ALLISON

CONCLUSIONS

(1) *Effect of Annealing Temperature and Duration.*—Under the conditions of the experiments, which were chosen to represent practical conditions as far as possible, it has been shown that substantial stress relief can be obtained by annealing at approximately the following minimum temperatures.

Admiralty gunmetal	500 deg. C.
High-tensile bronze	400 deg. C.
Cast iron	550 deg. C.
Carbon steel	600 deg. C.

TABLE IV.—*Stress Relief of Gunmetal and Bronze on Annealing.*

Specimen.	Annealing treatment.	Effective length. Ins.	Thickness. Ins.	Deflection. Ins.		Stress. Tons per sq. in.		Stress relief. Per cent.
				Initial.	Final.	Initial.	Final.	
Admiralty gunmetal.								
16 & 17	300 deg. C. for 3 hrs.	8.5	0.345	0.023	0.009	4.5	2.75	39
14 & 15	350 „ 3 „	8.5	0.356	0.0215	0.0115	4.35	2.0	53.5
18 & 19	250 „ 3 „	8.5	0.347	0.024	0.004	4.75	3.95	16.5
12 & 13	200 „ 3 „	8.5	0.378	0.0265	0.002	5.7	5.3	7.5
20 & 21	400 „ 3 „	8.5	0.375	0.0205	0.015	4.4	1.2	73
25 & 26	500 „ 3 „	8.5	0.375	0.0225	0.0225	4.8	0.0	100
High-tensile bronze.								
1 & 2	300 deg. C. for 3 hrs.	8.5	0.376	0.022	0.017	4.7	1.05	77.5
8 & 9	350 „ 3 „	8.5	0.338	0.0245	0.0225	4.7	0.4	92.5
3 & 4	250 „ 3 „	8.5	0.377	0.023	0.0125	4.9	2.3	54.5
5 & 6	200 „ 3 „	8.5	0.376	0.0235	0.0055	5.0	3.85	23.5
5a & 6a	400 „ 3 „	8.5	0.376	0.019	0.019	4.1	0.0	100

It has been shown that annealing grey cast iron appreciably in excess of 550 deg. C. will produce measurable growth.

It may also be pointed out that annealing certain steel castings, notably molybdenum steel castings, much in excess of 650 deg. C., but below the critical range, will bring about spheroidisation of the carbide constituent, possibly with very detrimental results as regards the creep strength of the material, i.e., the property for which these steels are particularly valuable.[3]

The effect of the length of the annealing period is of secondary importance at any rate within ordinary commercial foundry practice. The temperature : stress relief curves are steep, however, and for this reason it is essential that sufficient soaking should be allowed for the castings to attain the annealing temperature throughout. Under ordinary shop conditions there is generally a very big lag in temperature between the job and the control thermocouples unless a practice is made of deliberately placing thermocouples in suitable holes in the castings themselves, or, if not convenient, in holes drilled in blocks of metal of representative dimensions compared with the charge.

The experiments made show that it is quite erroneous to suppose that in iron or steel castings any large measure of stress relief can be obtained by ageing at atmospheric temperature or by annealing at temperatures such as 150 or 350 deg. C. The impression conveyed by some specifications in this respect is unfortunate.

(2) *Effect of Rate of Cooling after Annealing.*—The annealing treatments considered above will produce effective stress relief at the annealing temperature, but the parts when cold will not necessarily be still stress-free. Internal stresses are generally the result of uneven temperature distribution during cooling down, particularly whilst cooling through the temperature at which the material changes in character from plastic to elastic—say 600 to 350 deg. C. for steel and cast iron. Cooling from the stress-relieving temperature may set up a system of internal stresses therefore, as well as cooling after casting or after a high-temperature annealing treatment.

To avoid this possibility, furnace-cooling is recommended, and the authors' experience indicates that cooling in a closed furnace to 100 deg. C. is satisfactory even for such important steel castings as turbine cylinders and large steam-chests. Small parts of even section may be air-cooled without serious detriment, but it is difficult to draw the line in practice, since castings are not generally of even section and large temperature differences would be likely on cooling in air.

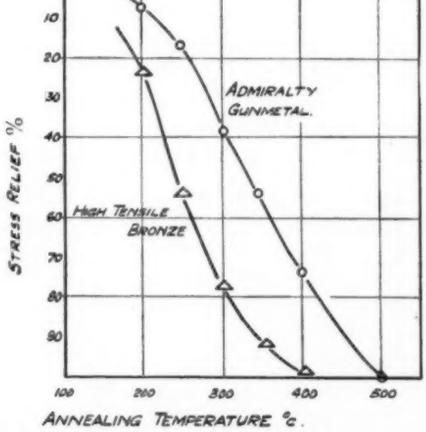


FIG. 6.—EFFECT OF ANNEALING TEMPERATURE ON STRESS RELIEF OF ADMIRALTY GUNMETAL AND HIGH-TENSILE BRONZE.

(3) *Generation of Internal Stresses.*—Steel castings are almost always annealed at a temperature in the region of 900 deg. C. and are frequently given a second treatment at 600 to 650 deg. C. after rough machining. In view of the fact that internal stresses become dissipated at about 600 deg. C., it is clear that the

internal stresses to which the engineer objects are not the result of cooling down after casting or forging as sometimes supposed, but have been developed by uneven cooling after annealing. It may even happen, through lack of appreciation of how internal stresses are developed and relieved, that the second annealing treatment is more detrimental than beneficial. For example, castings annealed at 900 deg. C. and slowly cooled may be internally stress-free and actually in better condition than after a second treatment followed by comparatively rapid cooling. It is the last treatment that counts, and in the authors' opinion one properly controlled heat-treatment is thoroughly satisfactory unless exceptionally heavy machining is done subsequently. In any case, one properly controlled annealing is preferable to repeated annealing treatments if due regard is not paid to the final cooling conditions.

As regards annealing stresses in steel parts, it is only fair to say that the authors' experience is that the foundry is less culpable than the forge. Whether iron foundries are in such a strong position is a debatable point, since many iron castings are not annealed at all. The need for annealing will depend, of course, on the degree of internal stress that can be tolerated and the uniformity of temperature that can be maintained as the castings cool down, particularly through the range 550 to 350 deg. C.

(4) *Magnitude of Internal Stresses.*—The stresses applied to the test-bars experimentally were chosen arbitrarily for convenience and to represent the magnitude of stress which the authors believe may exist. It is quite clear that much higher stresses can exist in castings since cracking does occur, but it is to be expected that such stresses would be dissipated at substantially the same temperatures as indicated by this investigation. This view is supported by the fact that stress relief curves obtained on steel using initial stresses of different magnitude tended to come together as the annealing temperature approached 600 to 650 deg. C.[1]

The authors are indebted to Dr. A. P. M. Fleming, C.B.E., director and manager of the research and education departments of Metropolitan-Vickers Electrical Company, Limited, for permission to publish the information contained in this Paper.

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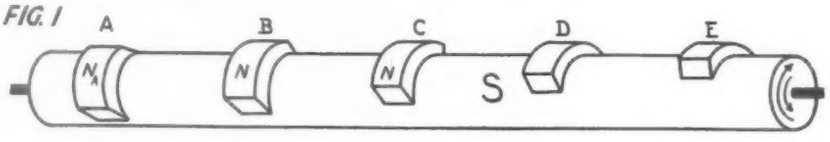
Carbon and Graphite Electrodes

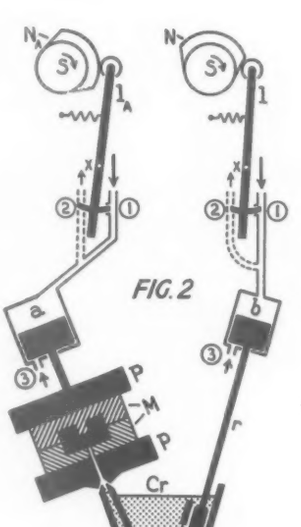
The results of comparative investigations of carbon and graphite electrodes for electric-arc steelmaking furnaces are described in a report by H. WEITZER, published in "Stahl und Eisen." The ohmic resistance of the graphite electrodes was found to be four to five times smaller than that of the carbon electrodes; the former could take up double the heat load of the latter as well as about three times the current density, which, however, depends on the diameter of the electrodes, than carbon electrodes can carry. In addition, electrode consumption with graphite electrodes is half that with carbon electrodes; the furnace lining is less affected with graphite electrodes, which reflects advantageously on costs. Carbon electrodes are the heavier and not so easy to manipulate. In spite of these advantages, the price of the graphite electrodes prevents them from competing with carbon electrodes. The cost of the graphite is three to six times that of the carbon, while the consumption is only half, so that the balance for the graphite to be competitive must be covered by savings in furnace lining, current consumption and increased output. Comprehensive calculations show that in spite of savings in these directions there is yet a marked increase in melting costs.

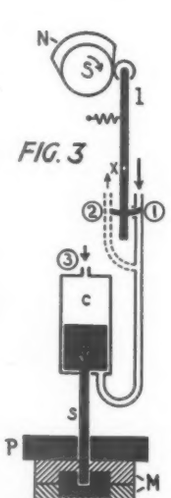
A Fully-Automatic Pressure Die-Casting Machine

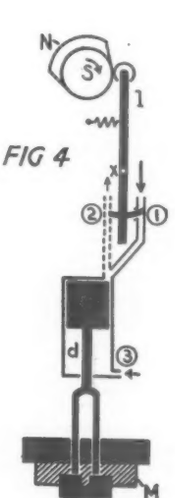
By Dr. A. STÄGER (Zurich)

A fully-automatic machine for making die-castings up to a pound has recently been constructed by Injecta, Limited, of Teufenthal, near Aarau (Switzerland). The central part of this "automatic" is the cam shaft S, represented in Fig. 1; the cams N are displaced one against the other. The cams (S in Figs. 2, 3 and 4) are in contact with the levers l_A and l, and by this means control all movements of the machine. The levers revolve round the axle X; they open or close the valves (1) and (2), and in this way hydraulic pressure may be admitted to the pressure cylinders a, b, c and d, or cut off. Fig. 2 represents, on the left, the process of opening and closing the dies, and, on the right, the injection process. If the lever l_A is in the position shown in Fig. 2, the valve (2) is closed and pressure is admitted through the tube (1). Therefore, the piston a is moved down and the plates P with the matrices M are closed. The lever l is shown after moving into such a position that pressure is admitted through the tube (1). Therefore, the piston b is moved down and its rod r is pushing another piston at its lower end into the gooseneck within the crucible Cr; in this way liquid metal is injected into the die cavities. If the valves (1) are closed and the hydraulic pressure is stopped, counter-pressure, acting through the tubes (3), will push the pistons a, b and c upwards again.









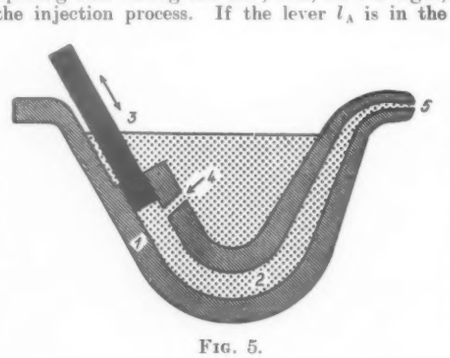


FIG. 5.

Fig. 3 shows the core withdrawal. If the camshaft be revolving in the direction indicated by the arrow, the lever l will turn round its axle X in the next moment; then valve (1) will be opened and valve (2) closed. The high-pressure water will enter through the pipe (1) and push the piston c upwards. In this way the core S will be withdrawn from the casting.

Fig. 4 represents the ejection process of the casting Ca. An interesting arrangement guarantees the regular backward movement of the camshaft after 180 deg. of revolution.

Some supplementary details may be given. The metal pot (Fig. 5) has an effective capacity of 175 to 200 lbs. of zinc alloy; 2 is the gooseneck, 3 the piston, 1 the surface of the metal pot exposed to the heat, 4 is the automatic valve, and 5 the injecting nozzle by which the liquid metal enters through 4 into the gooseneck.

In the "INCA 4" type of machine, the opening and closing movement is made in a horizontal direction (note that in Fig. 2 this arrangement has been changed in order to give a clearer synopsis).

The working speed of the machine can easily and smoothly be regulated by throttle valves which are interposed into the hydraulic pressure pipes. For each component to be cast the most suitable working speed can be chosen, which guarantees the highest rate of production which is possible for the component.

The "automatic" machine, type "INCA 4," is especially suitable for rapid mass production of small and medium pieces made of zinc, lead and tin alloys. The number of shots per minute with suitable castings reaches 1,500. The dies may be exchanged within 10 minutes. The machine can be operated by one unskilled workman, who has only to operate a single lever in order to start or stop the machine.

A Study of the Influence of Manganese on the Hardening and Tempering of Cast Iron

By J. E. HURST (Past President of the Institute of British Foundrymen)

This study of the influence of manganese follows upon somewhat similar lines the previous study[1] by the author of the influence of phosphorus on hardened and tempered cast iron.

Materials and Preparation of Samples

With slight variations the materials used and the methods adopted in the preparation of the samples and specimens followed along the lines described in the previous Paper[2]. The specimens used have been prepared from centrifugally cast drums and all the heat-treatment experiments have been carried out on the ring-form specimens machined from these drums. The castings were prepared from a chromium alloy material made from a mixture of West Coast hematite, phosphoric foundry pig-iron, refined chromium alloy pig-iron, and returned scrap. The manganese additions were obtained by the use of powdered ferro-manganese added to the molten cast iron in the ladle. Four sets of castings were prepared containing approximately 1.0, 1.5, 2.0. and 3.0 per cent. manganese. The chemical analyses of the specimens are given in Table I. These analyses reveal slight irregularities in the total carbon contents, but these are regarded as of a comparatively small order. The silicon content of specimen No. 3 is substantially lower than in the other specimens and the two high manganese specimens No. 3 and No. 4 show a very marked reduction in the sulphur content. This may be regarded as being due to the higher manganese contents. A point of some considerable interest and importance is the fact that the substantial increase in manganese is apparently without influence on the combined carbon content.

TABLE I.—*Percentage Chemical Composition of the Samples. "As Cast" Condition.*

Spec. no.	T.C.	C.C.	Gr.	Si.	Mn.	S.	P.	Cr.
1	3.44	0.79	2.65	2.43	0.91	0.074	0.63	0.27
2	3.58	0.83	2.73	2.41	1.43	0.063	0.62	0.26
3	3.48	0.72	2.76	2.09	2.00	0.036	0.63	0.20
4	3.37	0.86	2.51	2.34	3.10	0.034	0.64	0.21

Experimental and Testing Procedure

Ring specimens were machined from each casting and Brinell hardness determinations were made upon the complete set of all rings. The rings were divided into groups, one group being retained for the determination of the properties in the "as cast" condition. The other groups were arranged to enable the properties to be measured after:—(*a*) Hardening by oil-quenching; (*b*) hardening and tempering at various temperatures; (*c*) annealing; (*d*) annealing, hardening and tempering, and (*e*) effect of quenching temperature.

In each case hardening was carried out in an electric resistance furnace and tempering was also carried out in a similar type of furnace by raising the specimens to the required temperature and allowing them to soak for a quarter of an hour at the temperature followed by cooling in air.

The exact details[3] of the testing procedure adopted have been described previously and included the following properties:—(*a*) The Brinell hardness (Firth Hardometer 2 mm. ball 30 kg. load); (*b*) the EN value (modulus of elasticity); (*c*) the permanent set value, and (*d*) the tensile strength.

Test Results, "As Cast," Hardened and Tempered

These results are recorded in Tables II to V. In all cases of hardening, the specimens were quenched in oil from a uniform temperature of 875 deg. C. ± 5 deg. C.

TABLE II.—*Brinell Hardness Results.*

Mn, per cent.	0.91	1.43	2.0	3.10
Condition.				
As cast	234	255	305	305
Quenched in oil, 875 deg. C. ..	565	568	518	460
Do. do. Temp. 300 deg. C.	534	534	460	423
Do. do. Temp. 350 deg. C.	448	460	412	401
Do. do. Temp. 450 deg. C.	371	380	352	371
Do. do. Temp. 600 deg. C.	305	305	278	298

Brinell Hardness.—(Table II) The hardness in the "as cast" condition shows an increase with the manganese content up to 2.0 per cent. manganese. It is possible that, owing to the lower silicon content of this specimen, its hardness value is somewhat higher than would have been expected. If this be the case, it is probably true that the increase in manganese would have been accompanied by a regular increase in hardness in this condition. In the oil-quenched condition, the specimens containing 0.91 per cent. and 1.43 per cent. manganese attain a uniform hardness of 560 approximately. With higher manganese, the hardness level attained is less. In the tempered condition, the hardness is lowered with increasing tempering temperature, and at a tempering temperature of 600 deg. C. a hardness of 305 is obtained in the specimens containing 0.91 and 1.43 per cent. manganese, whilst the two specimens containing 2.0 and 3.10 per cent. manganese yield results lower than the original "as cast" condition.

TABLE III.—*Tensile Strength Results Expressed in Tons per in.*

Mn, per cent.	0.91	1.43	2.0	3.10
As cast	17.3	17.25	14.6	16.6
Quenched in oil, 875 deg. C. ..	8.25	9.8	7.5	9.7
Do. do. Temp. 300 deg. C.	17.9	14.8	14.0	16.8
Do. do. Temp. 350 deg. C.	19.15	19.5	13.7	13.9
Do. do. Temp. 450 deg. C.	16.5	13.7	13.7	14.9
Do. do. Temp. 600 deg. C.	17.4	14.5	14.5	16.9

Tensile Strength.—(Table III) The specimen containing 2.0 per cent. manganese is slightly out of step in the "as cast" condition, and it is uncertain whether this is to be ascribed to the lower silicon contents. Apart from this, the evidence seems to be that increase in manganese has a very slight effect only in lowering the tensile strength of the material in the "as cast" condition. In the oil-quenched condition a very substantial drop in strength is experienced. The effect of manganese on the magnitude of this drop in strength would appear to be in the direction of diminishing this. Tempering is accompanied by a recovery of the strength, but only in the lower manganese specimens is a value obtained which is substantially in excess of the strength in the "as cast" condition. This occurs at a tempering temperature of 350 deg. C., with values of 19.15 and 19.5 tons per in. squared in the specimens containing 0.91 and 1.43 per cent. manganese respectively, approximately 10 and 13 per cent. on the original "as cast" values. In the case of the 2.0 and 3.10 per cent. manganese specimens, whilst a recovery in strength is experienced, due to tempering, the values attained are only equal to those of the "as cast" condition.

TABLE IV.—*Permanent Set Results. Per cent.*

Mn, per cent.	0.91	1.43	2.0	3.10
As cast	16.4	13.2	10.8	10.0
Quenched in oil, 875 deg. C. ..	—	—	—	7.5
Do. do. Temp. 300 deg. C.	3.4	6.5	5.0	6.25
Do. do. Temp. 350 deg. C.	4.5	5.16	5.6	6.1
Do. do. Temp. 450 deg. C.	5.5	4.6	6.4	7.9
Do. do. Temp. 600 deg. C.	6.0	6.9	8.1	6.1

Permanent Set.—(Table IV) In all cases hardening and tempering is accompanied by a substantial drop in this value, and with increase in tempering temperature there is evidence of a steady recovery in the direction of the "as cast" value. With the maximum temperature of 600 deg. C. in these experiments, the permanent set did not recover to the extent of the original "as cast" value. In the "as cast" condition the permanent set evidently decreases with increase in manganese content. There is no evidence of any important influence of manganese on this value in the hardened and tempered condition.

TABLE V.—*EN Value (Modulus of Elasticity). Results, lbs. per in.* × 10.

Mn, per cent.	0.91	1.43	2.0	3.10
As cast	15.9	15.4	12.6	14.1
Quenched in oil, 875 deg. C. ..	9.3	8.7	11.3	14.0
Do. do. Temp. 300 deg. C.	15.0	8.5	13.8	13.6
Do. do. Temp. 350 deg. C.	10.4	13.7	13.0	14.1
Do. do. Temp. 450 deg. C.	10.2	12.1	10.0	15.0
Do. do. Temp. 600 deg. C.	17.6	14.9	14.6	13.9

EN Value (Modulus of Elasticity).—It seems probable that in the "as cast" condition this value undergoes a slight decrease with increase in manganese. There are a number of curious irregularities in the results obtained in the hardened and tempered condition. The values drop in the oil-quenched condition, and the extent of this drop is diminished with increase in manganese. With increase in tempering temperature, these values undergo recovery in the direction of the values in the "as cast" condition,

TABLE VI.—*Effect of Quenching Temperature in deg. C. on the Brinell Hardness.*

Deg. C.	Brinell hardness.											
	0.91 Mn.			1.43 Mn.			2.00 Mn.			3.10 Mn.		
700	250	226	226	250	235	235	266	250	245	255	255	245
750	—	—	—	226	235	240	226	245	226	—	—	—
775	235	226	226	235	235	240	255	235	245	240	255	255
800	—	—	—	235	209	235	258	255	245	—	—	—
825	412	435	412	460	390	390	488	502	518	502	488	460
850	—	—	—	488	488	488	460	460	460	—	—	—
875	565			568			518			460		

[1] J.I.S.I. No. 1, 1933.
[2] *Loc. cit.*
[3] Proceedings of the Institute of British Foundrymen, 1930-31, Vol. 24, page 373 and others; FOUNDRY TRADE JOURNAL, 1931, Vol. 45, page 345; 1932, Vol. 47, page 37.

and curiously, in specimens No. 1 and No. 3, a value in excess of the original "as cast" condition is obtained. This drop and subsequent recovery due to oil-quenching and tempering has been observed previously.[4] The results are given in Table V.

Effect of Quenching Temperature

Specimens were quenched in oil at successively increasing temperatures from 700 up to 815 deg. C. The hardness and strength results obtained are set out in Tables VI and VII. The effect of quenching from all temperatures up to 800 deg. C. is to bring about a slight lowering of the hardness from the value it possessed in the original "as cast" condition. This is in accordance with the experience recorded by Schwartz and Vath.[5] The magnitude of the drop in hardness due to quenching at 800 deg. C. is greater in the case of the high manganese specimens. In these instances the hardness is lowered from 305 to approximately 255 by quenching in oil from this temperature. An increase in hardening temperature of 25 deg. to 825 deg. C. is immediately accompanied by substantial hardening. In the specimens containing 2.0 per cent. and 3.10 per cent. manganese the maximum hardness is attained by quenching at 825 deg. C., but in the lower manganese specimens a quenching temperature of 875 deg. C. is necessary to attain the maximum. Quenching at temperatures from 700 up to 800 deg. C. in addition to bringing about a lowering of the

TABLE VII.—*Effect of Quenching Temperature in deg. C. on Tensile Strength.*

Deg. C.	Tensile strength. Tons per in.			
	0.91 Mn.	1.43 Mn.	2.00 Mn.	3.10 Mn.
700	15.99	18.33	17.98	17.80
750	—	16.28	20.34	—
775	17.69	18.87	17.67	17.28
800	—	18.01	18.88	—
825	16.63	14.31	13.97	11.70
850	—	15.93	14.17	—
875	8.25	9.8	7.5	9.7

Brinell hardness is accompanied by a general increase in tensile strength. The specimen containing 2.0 per cent. manganese shows a very substantial increase. Immediately quenching is accompanied by hardening as at 825 deg. C. a drop in tensile strength is experienced, although this is not so great in magnitude as the drop obtained by quenching at 875 deg. C.

Annealing Treatment

The effect of annealing on the hardness was investigated by submitting the test specimens packed in cast-iron borings to a temperature of 875 deg. C. for a period of one hour, followed by slow cooling in the furnace. The broken halves of the test rings from the previous hardening and tempering experiments were submitted to this same annealing treatment also, thus providing an opportunity of exploring the effect of annealing on the hardness of specimens which had been previously hardened and tempered. The results obtained are summarised in

TABLE VIII.—*Brinell Hardness after Annealing at 875 deg. C. for 1 hr.*

Mn, per cent.	0.91	1.43	2.00	3.10
As cast. Not annealed	234	255	305	305
As cast. Annealed	186	193	235	250
Oil quenched 875 deg. C. and annealed	183	201	235	235
Do. do. Temp. 300 deg. C. and annealed	186	230	240	235
Do. do. „ 350 „ „ „	186	217	226	235
Do. do. „ 450 „ „ „	209	205	230	255
Do. do. „ 600 „ „ „	217	201	240	240

Table VIII. The effect of this annealing treatment on the material in the "as cast" condition is to bring about a reduction in the hardness. It is of interest to note that the extent of this reduction due to annealing is no greater than that due to oil quenching at temperatures up to 800 deg. C. in the specimens containing 2.0 and 3.10 per cent. manganese. In the lower manganese specimens the reduction is greater. The specimens which had been previously hardened are softened by this treatment to about the same extent, and the same remarks apply to those specimens which had been previously hardened and tempered up to 350 deg. C. Not quite so large a drop in hardness is obtained by annealing those specimens which had been previously hardened and tempered at temperatures of 450 and 600 deg. C.

Annealing, followed by Hardening and Tempering

The effect of re-hardening and tempering these annealed specimens was investigated. The results obtained are summarised in Tables IX and X. In this case it will be appreciated that the effect of this is that some of the specimens have been submitted to hardening and tempering twice with the interposition of an annealing treatment. In all cases quenching in oil brings about a hardening effect, although the magnitude of this is not quite as great as the effect of direct quenching of the "as cast" material without the interposing of an annealing treatment. This is reflected in the hardness results after tempering which are substantially lower than those given in Table II.

Carbon Contents

A careful determination of the carbon contents of the specimens in the hardened and tempered condition was made. These determinations were made on samples from the actual specimens as heat-treated, of which the test results are given in Tables II to V. The total carbon and graphite contents were determined by combustion, and the combined carbon contents by difference. Duplicate determinations were made in each case, and in certain instances additional check determinations were made. The results are assembled in Table XI. In the oil-quenched condition there is clearly a diminution in the amount of graphite and an increase in the combined-carbon content. In the tempered condition this diminution in the graphite and increase in the combined-carbon content persists, and even shows an apparent tendency to increase in magnitude up to tempering temperatures of 350 and 450 deg. C., beyond which at a tempering temperature of 600 deg. C. a tendency to revert more nearly to the original "as cast" condition is shown. Whether any special significance is to be attached to this apparent tendency for the graphite to diminish and the combined-carbon content to increase, due to tempering, can be determined only by further experiment. The experimental procedure involving the treatment of separate specimens at each temperature introduces complications which may affect the magnitude of these changes in carbon contents. At this stage, therefore, it is only of importance to record these observations. The significance of these results for the purposes of this investigation lies in the fact that they afford additional evidence of the resolution of a portion of the graphite contents with a consequent increase in the combined carbon contents due to hardening and tempering; further, that tempering at the higher temperatures is accompanied by the reprecipitation of some of this redissolved graphite.

The behaviour of specimens No. 4 containing 3.10 per cent. manganese is rather difficult to interpret, but it does appear clear that the extent of this reabsorption of the graphite is substantially less in magnitude in this specimen.

TABLE IX.—*Brinell Hardness after Annealing at 875 deg. C. for 1 hr. followed by Quenching in Oil from 875 deg. C.*

Mn, per cent.	0.91	1.43	2.00	3.10
As cast, not annealed, quenched in oil	565	568	518	460
„ annealed, quenched in oil	416	441	511	489
Oil quenched from 875 deg. C., annealed, oil-quenched from 875 deg. C.	436	450	443	441
Oil quenched from 875 deg. C. Temp. 300 deg. C., annealed, oil quenched from 875 deg. C.	429	441	389	461
Oil quenched from 875 deg. C. Temp. 350 deg. C., annealed, oil quenched from 875 deg. C.	510	450	425	481
Oil quenched from 875 deg. C. Temp. 450 deg. C., annealed, oil quenched from 875 deg. C.	406	441	435	446
Oil quenched from 875 deg. C. Temp. 600 deg. C., annealed, oil quenched from 875 deg. C.	474	441	451	481

TABLE X.—*Brinell Hardness after Annealing at 875 deg. C. for 1 hr., followed by Quenching in Oil from 875 deg. C., and Tempering at Various Temperatures.*

Mn, per cent.	0.91	1.43	2.00	3.10
Annealed, oil quenched 875 deg. C. Temp. 300 deg. C.	353	390	396	376
Do. do. 875 „ „ 350 „	327	320	310	346
Do. do. 875 „ „ 450 „	309	276	330	325
Do. do. 875 „ „ 600 „	255	231	245	285

TABLE XI.—*Effect of Oil Quenching and Tempering on Condition of Carbon.*

Condition.	No. 1. Mn, 0.91 per cent.		No. 2. Mn, 1.41 per cent.		No. 3. Mn, 2.00 per cent.		No. 4. Mn, 3.10 per cent.	
	C.C. Per cent.	Gr. Per cent.	C.C. Per cent.	Gr. Per cent.	C.C. Per cent.	Gr. Per cent.	C.C. Per cent.	Gr. Per cent.
As cast	0.79	2.65	0.83	2.73	0.72	2.76	0.86	2.57
As cast. Oil quenched 875 deg. C.	0.93	2.50	0.99	2.58	0.98	2.50	0.87	2.50
As cast. Oil quenched 875 deg. C. Do. do. Temp. 300 deg. C.	0.98	2.49	1.15	2.40	1.13	2.35	0.88	2.51
Do. do. Temp. 350 deg. C.	1.03	2.40	1.26	2.20	1.19	2.29	0.92	2.45
Do. do. Temp. 450 deg. C.	1.08	2.35	1.15	2.46	1.19	2.29	1.07	2.30
Do. do. Temp. 600 deg. C.	0.87	2.56	1.05	2.56	1.15	2.35	1.02	2.35

[4] J.I.S.I. 1933, Vol. 1.
[5] "Die Giesserei," Vol. 21, page 345, 1934.

For High Quality Castings

The increasing demand for high-strength close-grained iron castings calls for improved metal. In comparison with the accepted standards of the past, the modern high quality casting requires lower total carbon and phosphorus, with a closer range in silicon. The Ironfounder can now meet this demand at a reasonable cost by the use of Stanton-Dale Refined Pig Iron.

Stanton-Dale is a pig iron of low total carbon, the graphitic carbon being uniformly distributed and of fine curly-flake formation. The close structure ensures remarkably high strength with good machineability, and Tensiles of 16 to 20 tons can readily be obtained when a proportion of Stanton-Dale Iron is introduced.

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Apart from this there is no clear evidence of any effect of manganese upon this phenomenon. The condition of the carbon was studied also in these specimens which had been hardened and tempered after having been previously subjected to an annealing treatment at a temperature of 875 deg. C. for one hour. The results are given in Table XII. Again in the quenched condition there has been a reabsorption of graphite, and again this absorption shows the apparent tendency to increase with increasing tempering temperatures up to 450 deg. C. The behaviour of specimen No. 4 containing 3.10 per cent. manganese under these conditions is more in line with that of the lower manganese specimens, although it is worthy of note that both this and the 2.00 per cent. manganese specimen No. 3 show a reasonably uniform absorption of graphite independently of the tempering temperature and little trace of the apparent tendency to increase with increasing tempering temperature. Apart from this there is again no clear evidence of any effect of manganese on this reabsorption of the graphite, and the special significance of these results lies in the fact that they confirm that this reabsorption of graphite takes place on hardening and tempering even after a preliminary annealing treatment.

TABLE XII.—*Effect of Annealing followed by Oil Quenching and Tempering on Condition of Carbon.*

Condition.	No. 1. Mn, 0.91 per cent.		No. 2. Mn, 1.41 per cent.		No. 3. Mn, 2.00 per cent.		No. 4. Mn, 3.10 per cent.	
	C.C. Per cent.	Gr. Per cent.	C.C. Per cent.	Gr. Per cent.	C.C. Per cent.	Gr. Per cent.	C.C. Per cent.	Gr. Per cent.
Annealed 875 deg. C. Quenched 875 deg. C.	0.98	2.48	0.99	2.56	1.24	2.24	1.19	2.20
Annealed 875 deg. C. Quenched 875 deg. C. Temp. 300 deg. C. ..	1.25	2.18	1.37	2.18	1.16	2.35	1.05	2.32
Annealed 875 deg. C. Quenched 875 deg. C. Temp. 350 deg. C. ..	1.08	2.35	1.48	2.07	1.19	2.29	1.08	2.38
Annealed 875 deg. C. Quenched 875 deg. C. Temp. 450 deg. C. ..	1.03	2.42	1.26	2.29	1.24	2.40	1.10	2.22
Annealed 875 deg. C. Quenched 875 deg. C. Temp. 600 deg. C. ..	1.00	2.50	1.26	2.29	1.13	2.35	1.25	2.14

Summary and General Conclusions

A number of properties of a series of centrifugally-cast chromium alloy cast irons containing varying amounts of manganese from 0.91 to 3.10 per cent. have been investigated in the "as cast," annealed and hardened and tempered conditions.

(1) The results show that in the "as cast" condition increase in manganese has apparently very little influence on the combined carbon content, but with 2.0 per cent. and over, a marked reduction in the sulphur content is brought about. The Brinell hardness is increased but the tensile strength, permanent set value, and the EN value are slightly lowered with increasing manganese content.

(2) Quenching from 875 deg. C. in oil is accompanied by a substantial increase in hardness and a marked drop in tensile strength, permanent set value, and also the EN value. Increase in manganese appears to bring about less drop in tensile strength and EN value when quenched from this temperature and also a lower hardness. The permanent set value does not appear to be affected by the manganese content.

Quenching in oil from all temperatures up to 800 deg. C. is accompanied by a lowering of the Brinell hardness. Above 800 deg. C. quenching is accompanied by an increase in hardness and in the higher manganese specimens (2.0 and 3.10 per cent. manganese) the maximum hardness is obtained by quenching at 825 deg. C. With lower manganese contents the higher temperature of quenching, viz., 875 deg. C., appears to be necessary to develop the maximum hardness. Quenching at temperatures up to 800 deg. C. is accompanied by a substantial increase in tensile strength, but immediately quenching is accompanied by hardening then there is a marked falling off in tensile strength.

(3) Tempering after quenching is accompanied by a recovery in the tensile strength and a reduction in the hardness value attained on quenching. The maximum recovery in strength occurs at a tempering temperature of 350 deg. C., but with the higher manganese contents the magnitude of this is not so great as in the lower manganese specimens where the strength attains a value in excess of that of the original "as cast" condition. It is possible that the higher manganese content specimens would yield better results if quenched at the lower temperature of 825 deg. C. With higher tempering temperatures the values of both strength and hardness are reduced further in the direction of those of the original "as cast" condition. The same remarks apply to the permanent set values and there is no evidence of any important influence of manganese on this value after tempering. The EN values also undergo recovery with tempering.

(4) Annealing is accompanied by a lowering of the Brinell hardness and increase in manganese appears to minimise the extent of this reduction. Quenching and tempering after annealing bring about hardening, but slightly less in magnitude than the direct quenching and tempering of the material from the "as cast" condition.

(5) An examination of the carbon contents shows that in the hardened and tempered condition reabsorption of the graphite takes place and this occurs also in the material which has been hardened and tempered after subjection to an annealing treatment.

The specimens used in this investigation were prepared by Sheepbridge Stokes Centrifugal Castings Company, Limited, and the whole of the experimental work and treatment carried out in the research laboratories of Bradley & Foster, Limited. Thanks are due to the directors of both these companies for the permission given to publish these results.

A New Portable Mould Dryer

For many years, Mr. E. Longden, the well-known foundry manager of Craven Brothers (Manchester), Limited, has taken a special interest in the question of portable mould dryers. This study has culminated in a patented design, the sales of which have been placed in the hands of the Fordath Engineering Company, Limited, Hamblet Works, West Bromwich. The construction of the stove is clearly shown in Fig. 1. The stove is available in two sizes, the larger being 4 ft. 6 in. wide and the smaller 3 ft. 3 in. The outer casing of the stove is made of mild steel plates welded at their edges to form a box. The casing is provided with two cast steel lugs of substantial dimensions for crane handling. Additionally, there are two brackets for positioning the stove on girders or the like, to be set over the mould to be dried. The steel plate, which, after encasing in firebricks, forms the back wall of the fire-box, is also welded into position.

The closure of the stove consists of an inner and an outer door, which, when closed, form a channel at the front of the stove. Down this channel air from the fan is blown to the underside of the fire-box. These doors are made of cast iron, the outer one being strongly ribbed and fitted with a catch and handle. The inner door is spaced by means of steel tubes or bolts, so as to form the width of the necessary air inlet. An additional air inlet or damper is attached to the inner door, which can be controlled by means of a rod protruding through the outer door. This damper allows air to be by-passed over the top instead of underneath the fire-box.

The cast-iron firebars are single pieces of deep section. They extend from the back wall to the inner door. Air is introduced by means of a motor-driven fan placed on the top and at the front edge of the stove; the larger model uses a fan of 800 to 1,000 cub. ft. of air per min., and the smaller size 500 to 600 cub. ft. The air passes down between the two doors, under the fire grate, through the fire and finally over the bridge and downwards to the opening placed beyond the back wall of the fire-box. The oven is lined with high-grade firebricks, siliceous insulation being inserted between the brickwork and the casing. The outer door is hinged on two substantial steel pins, which pivot in cast steel brackets welded on to the casing. To ensure a proper joint between the outer door and the casing, the inner facings of the door are machined and fit against flat mild steel strips welded to the casing. The larger and smaller stoves weigh 32 and 21 cwts. respectively.

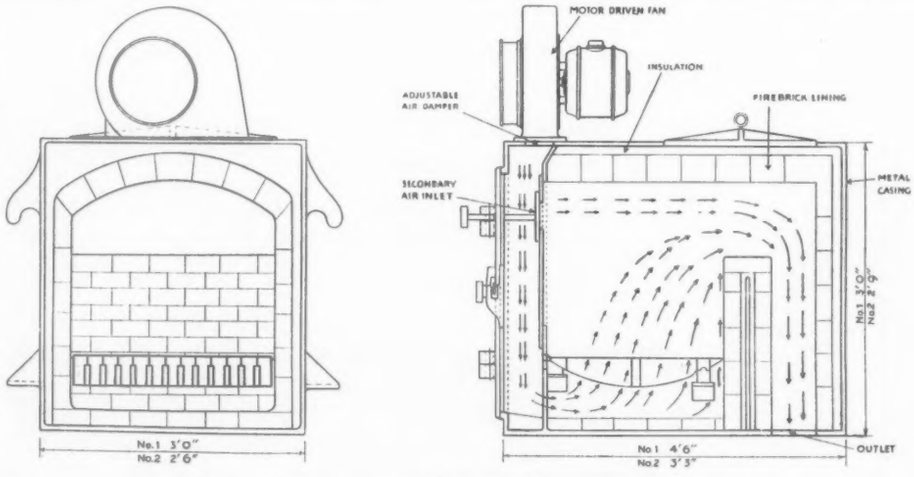

FIG. 1.—CONSTRUCTION OF PORTABLE MOULD-DRYING STOVE.

B.I. *MAGNETIC* MOULDING MACHINES

BRITISH PATENTS, 321777, 322728, 349173, 355889

THE ONLY MOULDING MACHINE IN THE WORLD WHICH UTILISES ELECTRICITY AS THE DIRECT POWER MEDIUM FOR HIGH PRODUCTION WORK.

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Operating costs are very low. Power is only used during the squeeze operation—approx. 2 seconds. Upkeep costs are very small. There are few moving parts, no glands or packings and no troublesome pipe lines.

If only A.C. is available a relatively small AC/DC convertor is required. A sequence relay device allows of operating a battery of machines from one convertor. Electric vibrators and heaters can be supplied if required. All parts are efficiently guarded against ingress of sand.

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BLOXWICH, STAFFORDSHIRE.

The Week's News in Brief

Trade Talk

THE KEIGHLEY ASSOCIATION OF ENGINEERS paid a visit yesterday to the works of the Renold & Coventry Chain Company, Limited, at Didsbury, Manchester.

THE JARROW WORKS of the British Oxygen Company, Limited, which were destroyed by fire and an explosion on February 19, have been rebuilt and production has been restarted.

THE PROSPECTUS was published last Thursday inviting applications for the cash portion (£466,300) of the £1,000,000 4 per cent. debenture stock, 1948-78, of the Stanton Ironworks Company, Limited.

THOS. C. KEAY, LIMITED, engineers and mill furnishers, of Dundee, have acquired the business and goodwill of Lee, Croll & Company, textile engineers and ironfounders, of Lawside Foundry, Dundee. The business was established in 1876.

EMPLOYEES OF Cruikshank & Company, Limited, founders, of Denny, went to Rothesay for their annual summer excursion, sailing down the Clyde from Glasgow. Rothesay was also the venue of about 470 employees of John G. Stein & Company, Limited.

THE L.N.E.R. COMPANY has placed a contract with the Birmingham Railway Carriage & Wagon Company, Limited, for 30 non-vestibuled carriages consisting of 15 twin sets, and another contract with the Metropolitan Cammell Carriage & Wagon Company, Limited, for 42 carriages consisting of 21 twin sets.

THE PALLION INDUSTRIAL SITE at Sunderland was opened on Wednesday by Sir George Gillett, Commissioner for the Special Areas. Occupying 18 acres, it is served by the L.N.E.R. main line and is within a mile of Sunderland Corporation Quay. Development of the site was undertaken by North Eastern Trading Estates, Limited.

THE ANNUAL INSPECTION of the National Physical Laboratory by the General Board took place on Tuesday afternoon. Some 1,500 visitors were received by Sir William Bragg, O.M. (President of the Royal Society, and chairman of the General Board), Lord Rayleigh (chairman of the Executive Committee) and Dr. W. L. Bragg (Director of the Laboratory).

A SCHEME for awarding apprenticeship certificates to youths on attaining the age of twenty-one was introduced in 1932 in the engineering and allied trades in Birmingham and district. In the Birmingham Council Chamber on June 21 the Lord Mayor distributed 88 certificates to qualified candidates employed by the General Electric Company, Limited, and other firms.

AN 85-TON CAST-STEEL MILL HOUSING has left the works of Lamberton & Company, Coatbridge, on a 400-mile journey which will take a week to complete. Its destination is the new works of Richard Thomas & Company, Limited, at Ebbw Vale. The housing is being transported on a 16-wheel Diesel-engined wagon, of which there are only three in this country. The second housing for the mill will leave Coatbridge in about a week's time.

DEMONSTRATIONS OF the rumbler type of "Sand Wizard" were given in the Manchester district recently by the Constructional Engineering Company, Limited, of Titan Works, Charles Henry Street, Birmingham. The machine installed for the purpose was the 44-in. by 40-in. type, capable of cleaning castings from a few ounces in weight up to 2 cwts. Local foundry executives were invited to inspect the machine in operation and to submit castings of their own manufacture for sand-blasting therein.

MR. JUSTICE HUMPHREYS, in the King's Bench Division, assessed at £12,000 damages in an action in which Mr. Alan Shirlaw sued Southern Foundries (1926), Limited, Croydon, and Federated Foundries, Limited, of Glasgow, for wrongful termination of his contract as managing director of the former company. Judgment, with costs, had previously been entered in favour of Mr. Shirlaw. He claimed that his employment was terminated two years after Federated Foundries, Limited, had acquired a controlling interest in Southern Foundries, while his contract was for ten years.

REDUCTION of the capital of Sir W. G. Armstrong Whitworth & Company (Engineers), Limited, Scotswood Works, Newcastle, from £1,500,000 to £1,000,000 by returning £500,000 to the sole shareholder, Armstrong Whitworth Securities Company, Limited, as capital in excess of the company's wants, was confirmed in the Chancery Division recently. It was stated that under a scheme of arrangement sanctioned in 1929 various operating companies were formed to take over the different activities of Sir W. G. Armstrong, Whitworth & Company, Limited. This company took over the engineering side, with works at Gateshead and Scotswood. The Gateshead works subsequently were sold back to the parent company, and the Scotswood works had now been sold to the Admiralty. The work of the company was now restricted to maintenance and service obligations under existing contracts.

THROUGH the intervention of Mr. Subhas Chandra Bose, the President of the Indian National Congress, the dispute between the Tata Iron & Steel Company, Limited, and its employees has been settled and the strike has been called off. By the terms of settlement. the company will give the workers an additional half-month's bonus, bringing the total bonus to three months instead of two and a half months as contemplated. The question of an extension of the general production bonus to all workmen and revision of the gratuity rules are understood to have been left for inquiry by a Labour Committee of which the chairman will be a member of Congress, while the revision of the departmental bonus, including the cases of men in the electrical and mechanical departments, will be considered by another committee. The company has declined to consider the alteration of the basis of the profit-sharing scheme.

OWING to shortage of skilled men some of the employees of the English Steel Corporation, Limited, are working 65 hours weekly, said Mr. A. B. Winder, joint general manager and director, at the annual sports day of the firm, held recently at Shiregreen, Sheffield. Employees at the Sheffield works to-day numbered 9,600, compared with 3,500 a year ago. During the past few months they had been gradually manning new machine shops, and it was here that long hours were being worked owing to shortage of skilled men. Mr. Winder said he would like to be able to get enough suitable labour to have three shifts working. The directors desired the men to have adequate time free for sport and recreation. He was confident about the future and said they could look forward to regular work during the next twelve months in almost all departments—unless something very unexpected happened.

Personal

MR. JOHN B. KINROSS has joined the board of the Newall Engineering Company, Limited.

MR. B. C. STUDD has been appointed a director of the Indian Iron & Steel Company, Limited, in place of Mr. Eric Studd, who has resigned.

MR. M. P. APPLEBY, research manager of Imperial Chemical Industries, Limited, at Billingham, received the honorary degree of D.Sc. at the Durham University Convocation on June 28.

MR. ROBERT H. HEYER, junior metallurgist in the Research Laboratories of the American Rolling Mill Company, has been awarded the Charles B. Dudley Medal of the American Society for Testing Materials for 1938. This medal commemorates the name of the first President of the Society.

MR. CHRISTOPHER WILSON and MR. SIDNEY D. WHITE, two of the directors of the General Electric Company, Limited, have each completed fifty years' service with the company. Lord Hirst of Witton, chairman and managing director of the company, on behalf of himself and his colleagues of the board, made a presentation to Mr. Wilson and Mr. White at a dinner at Claridge's Hotel, London.

Obituary

MR. JAMES CARTER, head of the firm of James Carter & Sons, Woodyard Engineering Works, Norden, Rochdale, died recently, aged 74 years.

DR. C. E. GUILLAUME, the director since 1915 of the International Bureau of Weights and Measures in Paris, has died. He was known for his invention of invar, an alloy of iron and nickel, and of elinvar, an alloy of iron, nickel and chromium. He was the author of numerous works on alloys, and received the Nobel Prize in 1920.

Company Reports

R. A. Lister & Company, Limited.—Interim ordinary dividend of 5 per cent.

Baker Perkins, Limited.—Net profit, £86,105; dividend of 6 per cent.; to general reserve, £20,000.

Newall Engineering Company, Limited.—Net profit to March 31, £12,875; brought in, £3,382; dividend on "A" and "B" ordinary shares of 10 per cent.

Wolverhampton Die-Casting Company, Limited.—Half-yearly dividend on the 6 per cent. cumulative preference shares for the period from December 17, 1937, to June 30, 1938.

General Electric Company, Limited.—Profit for the year ended March 31, £1,772,181; brought in, £749,294; depreciation, £368,642; directors' remuneration, £4,287; contribution to pension fund, £54,008; dividend of 6½ per cent. on the "A" preference stock, £86,288; dividend of 7½ per cent. on the "B" preference stock, £99,552; to taxation reserve, £400,000; to reserve, £100,000; dividend of 10 per cent. on the ordinary stock, £304,382; bonus of 10 per cent., £304,382; carried forward, £799,934.

Contracts Open

Douglas (I. o. M.), July 2.—Iron and steel, for the Town Council. The Borough Surveyor, Town Hall, Douglas, I.o.M.

Plymouth, July 7.—Supply and erection of plant manufacturing sulphate of ammonia, for the Town Council. Mr. F. Blackburn, Gas Department, Devonport.

Cairo, August 24.—Supply and erection of pumping plant, for the Egyptian Ministry of Public Health. The Department of Overseas Trade. (Reference T.Y. 23,120/38.)

Buenos Aires, August 22.—Six electric pumping sets, etc., for the Argentine National Sanitation Works Department. The Department of Overseas Trade. (Reference T.Y. 23,107/38.)

New Companies

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

Rhodnel Engineering Company, Limited, 16, Clegg Street, Oldham.—Capital, £1,000. Directors: F. Schofield, J. Hirst, and H. Sutcliffe.

J. T. Gibson & Sons, Limited, 43, Lambeth Road, Reddish, Stockport.—Capital, £5,000. Ironfounders, etc. Directors: J. Gibson and J. H. Gibson.

Brassfounders (Bradford), Limited, Crag Works, Great Horton Road, Great Horton, Bradford.—Capital, £1,500. Directors: N. Smith and J. W. Howarth.

Iron and Steel Institute and Institute of Metals New Offices

The offices of the Iron and Steel Institute and of the Institute of Metals will be moved to 4, Grosvenor Gardens, London, S.W.1, as from July 1, 1938. The Institutes will occupy separate offices in this house but will share committee and reading rooms. Correspondence should be addressed to the Secretary of the Institute concerned. The libraries of the two Institutes have been joined. The joint library will be operated in the equal interests of the two Institutes by the librarian of the Iron and Steel Institute, who will have the guidance of a Joint Advisory Committee appointed by the Councils of the two Institutes.

The information service conducted by the Iron and Steel Institute with the support of the Iron and Steel Industrial Research Council and that conducted by the Institute of Metals will be extended. Members of both Institutes or of the British Iron and Steel Federation and others wishing to avail themselves of this service, or to obtain information on technical publications, specialised bibliographies, abstracts, etc., should apply to the Librarian.

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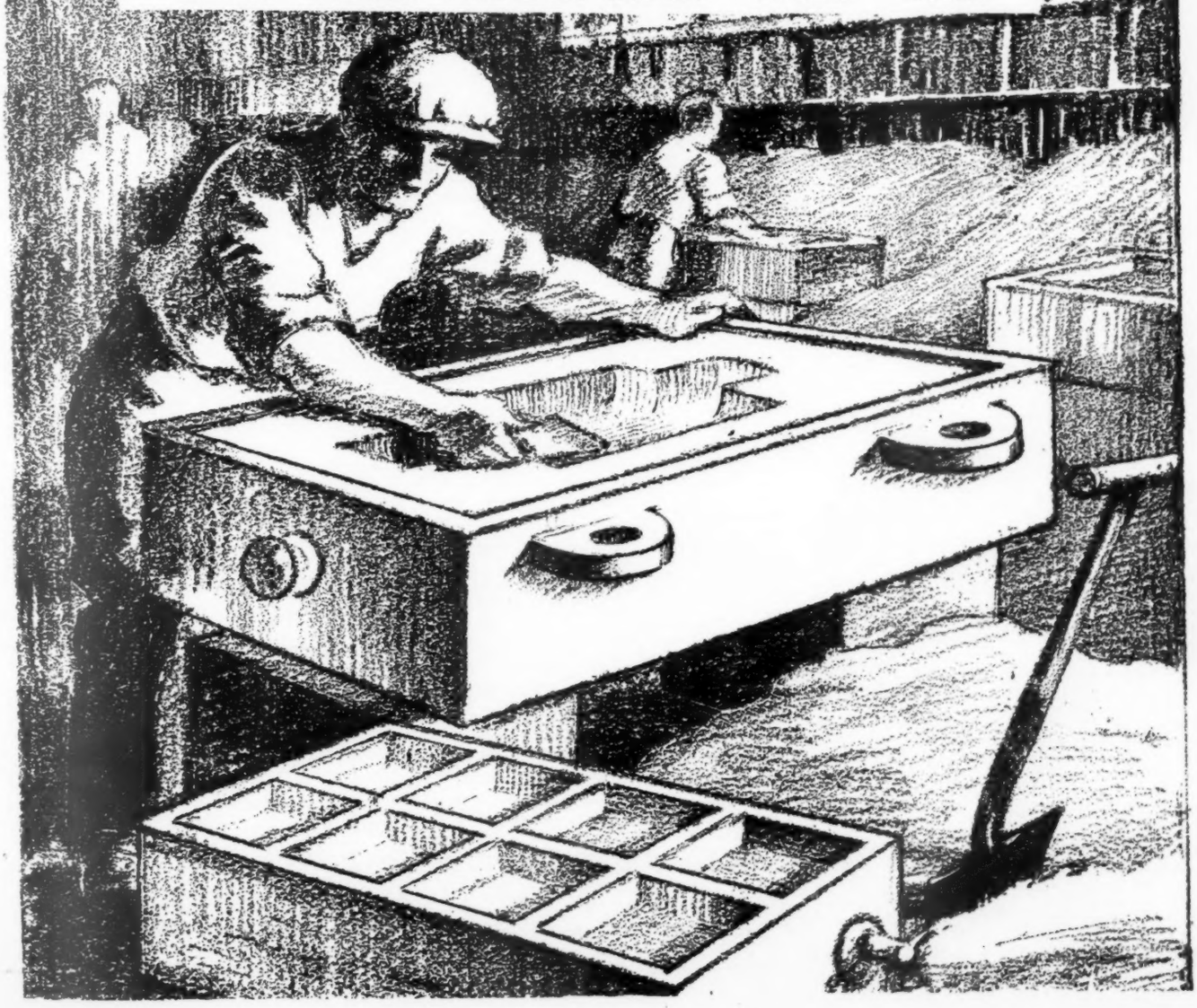
SCOTTISH OFFICE: 48, West Regent Street, Glasgow, C.2. Telephone: Douglas 6108 (3 lines). Telegrams: "Genefax, Glasgow."

SWANSEA OFFICE: Metropole Chambers, Wind Street. Telephone: 3680. Telegrams: "Genefax, Swansea." (Mr. D. F. Hood-Williams).

MANCHESTER OFFICE: 9, Albert Square. Telephone: Blackfriars 6130. Telegrams: "Genefax, Manchester." (Mr S. G. Throssell).

MIDDLESBROUGH OFFICE: Halifax Bldgs., Exchange Place. Telephone Middlesbrough 3313. Telegrams: "Genefax, Middlesbrough." (Mr J. A. Williams).

BIRMINGHAM OFFICE: 5, Lower Temple Street. Telephone: Midland 6376. Telegrams: "Genefax, Birmingham." (Mr. G. Griffiths)



Raw Material Markets

The past week has not witnessed any improvement in business in the pig-iron market and consumers continue to rely on their stocks to meet current requirements. At present, there is no indication of when it will become necessary to buy further supplies; the position in this respect, of course, varies considerably, but it is known that many of the larger consumers are in possession of substantial tonnages. Although production has been appreciably reduced from the levels reached a few months ago, makers have not cut their outputs so much as might have been expected in the circumstances.

Pig-Iron

MIDDLESBROUGH.—Consumers in this area continue to draw on their stocks and new business is almost non-existent. A few small tonnages are changing hands, but users are not entering into long-term contracts. Even if there were any necessity to take up further supplies, it is doubtful whether consumers would buy very far ahead, as producers are in the position to make prompt deliveries for a long time hence. It is said that shipments from the Tees to coastal and foreign ports were heavier even during the general strike of 1926 than they are at the present time. For delivery to Middlesbrough and Falkirk, No. 3 Cleveland G.M.B. foundry iron is quoted at 109s., No. 1 foundry 111s. 6d., and No. 4 foundry and No. 4 forge 108s., these prices being stabilised up to the end of the year.

Many consumers continue to call for restricted deliveries of hematite under existing contracts, and new business involves only small tonnages. Consequently, stocks at the producing end are mounting up. Prices for export are considerably below those ruling for home transactions, but, even so, new business is negligible.

LANCASHIRE.—There continues to be some slight improvement in the condition of the light-castings trade, but this section is still much below the normal rate of activity for the time of the year. Textile machinists, also, are a little better situated, but orders to this branch remain unsatisfactory. The Chinese war has adversely affected business in the textile industry. On the other hand, the heavy electrical and machine-tool trades are busy and taking up large tonnages of pig-iron. In addition to home orders, quite a satisfactory number of inquiries is coming in from abroad. The jobbing foundries are rather less well employed.

MIDLANDS.—Business in pig-iron continues to be on the quiet side, largely as the result of the slackness of the light-castings trade. This section has improved to some extent, but there is still an abnormal lack of orders. Most foundry iron producers have substantial stocks on hand. Some forward business is being entered into, but, on the whole, consumers will only buy small tonnages for prompt delivery. Low-phosphorus iron continues to be fairly well taken up, but the demand for hematite remains rather quiet, although some expansion has recently set in. The price of the former varies according to the source of supply from £5 15s. to £7 per ton. The higher priced material is received from Scotland.

SCOTLAND.—The holiday period will shortly commence in this area, and the quietness of the market will be accentuated. Some concerns, notably the light-castings makers, are already only working a few days per week, owing to the scarcity of orders. No expansion in the demand for pig-iron is anticipated for several months. No. 3 foundry iron is quoted at 118s., f.o.t. furnaces, with No. 1 at 120s. 6d. There is no demand at all for Cleveland iron. Most of the local steelworks are active, but are not taking further supplies of pig-iron, as, in most cases, they are covered at least up to the end of the year. Hematite mixed numbers are quoted at 133s., Scottish basic 107s. 6d., and English and Indian basic 100s., all less 5s. per ton rebate, delivered local steelworks.

Coke

Users of foundry coke continue to refrain from making new purchases. Consumption is always rather less at this period of the year and it is unlikely that there will be any new business about until the autumn. For delivery to Birmingham and Black Country stations, best Durham foundry coke is quoted at 50s. 6d., with Welsh at 50s. 6d. upwards.

Steel

A rather brighter tone has made itself felt in the steel market during the past week, and, although conditions generally are quiet, inquiry has been more active, states the official report of the London Iron and Steel Exchange. The demand for semi-finished steel shows little sign of improving, and most consumers appear to have sufficient material in stock to last them for some time, while others have contracts covering their forward requirements. In the finished steel section of the market, more cheerful conditions have developed than have ruled for some weeks. The heavy-steel department of the industry is well provided with work, and lately consumers have shown rather more interest in new business. The lighter branches of the trade, which have been suffering from a lack of orders for some weeks, have also experienced a slight expansion in demand. Export business remains quiet, but with some overseas markets, business has been a little more active.

Scrap

The turnover in scrap remains restricted both as regards iron and steel. Heavy stocks are on hand at the consumers' end, and until these are considerably lowered new business will be very scarce. Consumption at the steelworks is still satisfactory in most instances, but here, again, requirements are well covered ahead.

Metals

The non-ferrous metal markets have been more cheerful this week, largely as the result of improved news from the United States, and, in tin, of the clearer outlook with regard to the buffer pool.

Copper.—This market has been quite firm and the demand for refined copper has been on a good scale. The tone of the market reacted favourably to the stronger stock markets in New York, but it is doubted whether this will be maintained for long, as the relationships between the business world and the White House are still rather antagonistic.

Speaking at the annual meeting of the Copper Development Association on Thursday last, Mr. D. Owen Evans, chairman, was able to outline the further increase in the scope of the activities of the Association in the past year, and the demands made by all sections of the copper-using industries upon the services it had to offer. The report of the Association referred to developments in connection with the widespread use of copper in the electrical, building and general engineering industries. It was apparent, it said, that the Association was fulfilling an important function in bridging the gap between the highly technical and purely practical sides of industry.

Metal Exchange quotations were as follow :—

Cash.—Thursday, £36 12s. 6d. to £36 13s. 9d.; Friday, £37 7s. 6d. to £37 10s.; Monday, £37 16s. 3d. to £37 17s. 6d.; Tuesday, £37 3s. 9d. to £37 6s. 3d.; Wednesday, £36 13s. 9d. to £36 16s. 3d.

Three Months.—Thursday, £36 16s. 3d. to £36 17s. 6d.; Friday, £37 13s. 9d. to £37 15s.; Monday, £38 2s. 6d. to £38 3s. 9d.; Tuesday, £37 10s. to £37 11s. 3d.; Wednesday, £37 to £37 1s. 3d.

Tin.—The recent strength of this market has been chiefly due to speculative interest and to the decision of the International Tin Committee to bring the buffer pool into operation on July 1. With regard to the latter, it is understood that Siam will not participate in the scheme. That country is expected to protest against the grant of an additional 7½ per cent. of standard tonnages to Malaya and the Dutch East Indies. Siam's minimum quota is to be reduced by the tonnage she would otherwise produce for the pool.

The June issue of the Statistical Bulletin of the International Tin Research and Development Council states that world tin production in the first four months of this year amounted to 57,800 tons, or 14,450 tons per month on an average, against a monthly average of 17,370 tons for the whole year 1937. World apparent tin consumption in the first four months of 1938 amounted to 52,700 tons, or 13,200 tons per month on an average, against 16,500 tons in 1937. Apparent consumption in the United Kingdom in May at 1,436 tons was 1,000 tons under the figure for April. World tinplate production in the first four months of 1938 amounted to 910,000 tons, or 228,000 tons (against 355,000 tons in 1937) per month on an average. Production in May is estimated at 223,000 tons, against 394,000 tons in May, 1937. The complete tin statistics for May are not yet available.

Official quotations were as follow :—

Cash.—Thursday, £186 5s. to £186 15s.; Friday, £187 10s. to £187 15s.; Monday, £187 5s. to £187 15s.; Tuesday, £185 5s. to £185 7s. 6d.; Wednesday, £184 to £184 10s.

Three Months.—Thursday, £187 5s. to £187 10s.; Friday, £188 15s. to £189; Monday, £188 to £188 5s.; Tuesday, £186 to £186 5s.; Wednesday, £185 5s. to £185 10s.

Spelter.—Consumers have come into the market a little more freely during the past week and the market exhibits a stronger tone. The weekly market report issued by Rudolf Wolff & Company states that "business with consumers has broadened, but demand in this direction has not in itself been sufficiently good to warrant the advance which has taken place, and the rise, therefore, must be more particularly attributed to sentiment and a realisation that the present level of prices leaves room for further moderate advance. It seems not unlikely, however, that consumers will in turn be attracted if the present improvement is sustained, in which case a further rise might reasonably be anticipated."

Daily market prices :—

Ordinary.—Thursday, £13 18s. 9d.; Friday, £14 1s. 3d.; Monday, £14; Tuesday, £13 5s.; Wednesday, £13 8s. 9d.

Lead.—In sympathy with the trend in other metals there has been an upward movement in lead. New business, however, is still quiet and most of it emanates from speculative sources. Speaking at the annual meeting of Selection Trust, Limited, the chairman, Mr. A. Chester Beatty, said that he felt it would be a wise step for producers of zinc and lead to study once again the possibilities of active co-operation. He referred to the satisfactory operation of the copper control scheme.

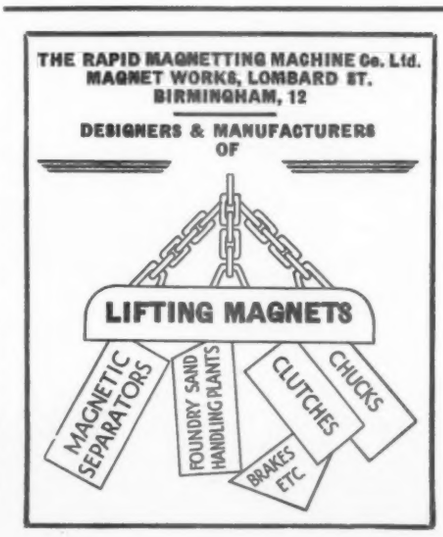
The position of the building industry is less satisfactory, with activity below a year ago, though still at a high level, states the current issue of the "Building Industries Survey," published by the Building Industries National Council. The seasonal improvement has failed to attain its usual dimensions, and it is reasonably certain that activity and employment will be lower in 1938 than in 1937. Evidence of the recession accumulates.

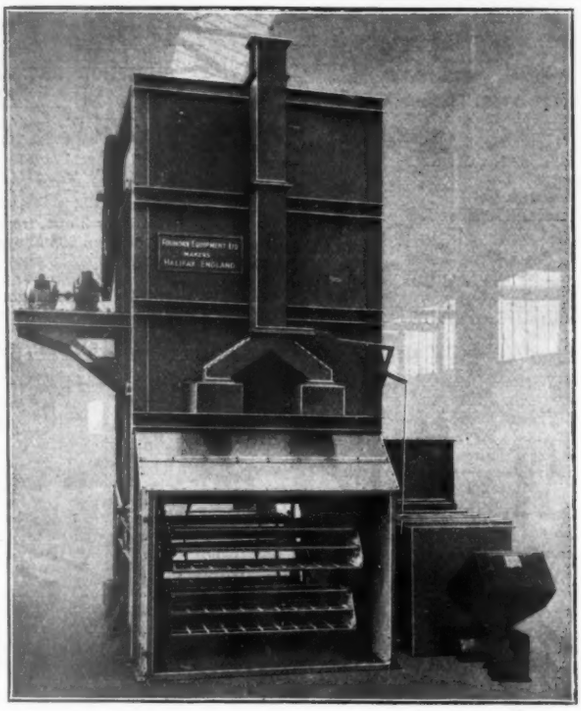
Day-to-day quotations :—

Soft Foreign (Prompt).—Thursday, £14 17s. 6d.; Friday, £14 17s. 6d.; Monday, £15 1s. 3d.; Tuesday, £14 7s. 6d.; Wednesday, £14 6s. 3d.

Scrap.—The improvement in virgin metals has been reflected in the demand for scrap. This expansion may be no more than a temporary movement, although it is quite time that consumers took in further supplies. Prices, generally, are higher on the week.

Approximate selling prices for old metal:—New aluminium cuttings, £73; rolled, £58; cast, £28 to £29; foil, £88. Copper, £32 to £35; braziery, £28 to £29. Brass (clean), £20 to £24. Zinc, £8. Lead, £12 10s. Gunmetal, £35 to £36.





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RAW MATERIALS—PRICE LIST

(Wednesday, June 29, 1938)

COPPER

	£	s.	d.
Standard cash	36	13	9
Three months	37	0	0
Electrolytic	40	15	0
Tough	40	0	0
Best selected	40	10	0
Sheets	71	10	0
India	53	2	6
Wire bars	41	15	0
Ingot bars	41	15	0
H.C. Wire rods	45	5	0
Off. av. cash, May	36	14	$2\frac{5}{11}$
Do., 3 mths., May	36	19	$0\frac{9}{22}$
Do., Sttlmnt., May	36	14	$2\frac{5}{11}$
Do., Electro, May	41	5	$1\frac{4}{11}$
Do., B.S., May	40	15	10
Do., Wire bars, May	41	13	$2\frac{8}{11}$
Solid drawn tubes			12d.
Brazed tubes			12d.
Wire			$7\frac{1}{2}$d.

BRASS

Solid drawn tubes	11d.
Brazed tubes	13d.
Rods, drawn	$8\frac{1}{2}$d.
Rods, extd. or rlld.	6d.
Sheets to 10 w.g.	$8\frac{1}{4}$d.
Wire	$7\frac{1}{2}$d.
Rolled metal	$7\frac{1}{2}$d.
Yellow metal rods	6d.

TIN

	£	s.	d.
Standard cash	184	0	0
Three months	185	5	0
English	184	0	0
Bars	186	0	0
Straits	187	0	0
Eastern	188	17	6
Banca (nom.)			—
Off. av. cash, May	162	16	$8\frac{5}{11}$
Do., 3 mths., May	163	8	9
Do., Sttlmt., May	162	16	$9\frac{9}{11}$

SPELTER

	£	s.	d.
Ordinary	13	8	9
Remelted	10	5	0
Hard	9	15	0
Electro, 99·9	17	6	3
English	14	10	0
India	12	15	0
Zinc dust	18	5	0
Zinc ashes	5	10	0
Off. aver., May	12	15	$6\frac{3}{32}$
Aver., spot, May	12	13	$7\frac{7}{11}$

LEAD

	£	s.	d.
Soft foreign, ppt.	14	6	3
Empire (nom.)	15	3	9
English	16	10	0
Sheets, home	22	10	0
Do. export	18	17	6
Pipes, home	22	0	0
Do. export	19	10	0
Tea lead	31	0	0
Off. aver., May	14	5	$10\frac{35}{88}$
Aver., spot, May	14	4	$2\frac{5}{11}$

ALUMINIUM

Ingots	£100 to £105
Wire	1/3 to 1/4 lb.
Sheet and foil	1/2½ to 1/4 lb.

ZINC SHEETS, &c.

Zinc sheets, English	27	15	0 to 28	5	0
Do., V.M. ex-whse.	27	15	0 to 28	5	0
Rods			18	10	0

ANTIMONY

English	70	0	0 to 71	0	0	
Chinese, ex-whse.			51	0	0	
Crude, c.i.f.			30	0	0	

QUICKSILVER

Quicksilver	13	15	0

FERRO-ALLOYS AND STEEL-MAKING METALS

Ferro-silicon—						
25%	12	10	0			
45/50%	12	10	0			
75%	17	0	0			
Ferro-vanadium—						
35/50%	14/- lb. Va.					
Ferro-molybdenum—						
70/75% carbon-free	4/9 lb. Mo.					
Ferro-titanium—						
20/25% carbon-free	9d. lb.					
Ferro-phosphorus, 20/25%	£21 to £22					
Ferro-tungsten—						
80/85%	4/8 lb.					
Tungsten metal powder—						
98/99%	4/9½ lb.					
Ferro-chrome—						
2/4% car.	34	15	0			
4/6% car.	24	5	0			
6/8% car.	24	0	0			
8/10% car.	24	0	0			
Ferro-chrome—						
Max. 2% car.	36	0	0			
Max. 1% car.	38	5	0			
Max. 0·5% car.	41	0	0			
70% carbon-free	10d. lb.					
Nickel—99·5/100%	£180 to £185					
"F" nickel shot	£165	0	0			
Ferro-cobalt, 98/99%	8/6 to 8/9 lb.					
Metallic chromium—						
96/98%	2/5 lb.					
Ferro-manganese—						
76/80% loose	£18	15	0 to 19	5	0	
76/80% packed	£19	15	0 to 20	5	0	
76/80% export	£16	0	0 to 17	0	0	
Metallic manganese—						
94/96% carbon-free	1/3 lb.					

Per ton unless otherwise stated, basis 2-ton lots.

SCRAP

	£	s.	d.	£	s.	d.
South Wales (West)—						
Heavy steel, best	3	8	9 to 3	11	3	
Mixed iron and steel	3	6	9 to 3	9	3	
Heavy cast iron	3	8	9 to 3	11	3	
Good machinery	3	10	0 to 3	12	0	
Cleveland—						
Heavy steel, best	3	7	0 to 3	9	6	
Steel turnings	2	13	0 to 2	15	6	
Heavy cast iron			3	10	0	
Heavy machinery			3	15	0	
Midlands—						
Short heavy steel	3	10	0 to 3	12	6	
Light cast-iron scrap			3	2	6	
Heavy wrought iron	4	0	0 to 4	5	0	
Steel turnings	2	6	3 to 2	8	9	
Scotland—						
Heavy steel best	3	5	0 to 3	7	6	
Ordinary cast iron	3	11	3 to 3	12	6	
Cast-iron borings	2	0	6 to 2	3	0	
Wrot-iron piling	3	15	0 to 3	17	6	
Heavy machinery	3	13	6 to 3	16	3	

London—Merchants' buying prices, delivered yard.

Copper (clean)	29	0	0
Brass	18	0	0
Lead (less usual draft)	12	10	0
Tea lead	9	0	0
Zinc	6	10	0
New aluminium cuttings	65	0	0
Braziery copper	25	0	0
Gunmetal	30	0	0
Hollow pewter	125	0	0
Shaped black pewter	85	0	0

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten	3s. 0d.
Finished bars, 18% tungsten	3s. 10d.

Per lb. d/d buyers' works.

PIG-IRON*

N.E. Coast (d/d Tees-side area)—	
Foundry No. 1	111/6
" No. 3	109/-
" No. 4	108/-
Forge No. 4	108/-
Hematite No. 1	133/-
Hematite M/Nos.	132/6
N.W. Coast—	
Hem. M/Nos. d/d Glas.	133/-
" d/d Birm.	144/6
Malleable iron d/d Birm.	160/-
Midlands (d/d Birmingham dist.)—	
Staffs No. 4 forge	110/-
" No. 3 fdry.	111/-
Northants forge	107/6
" fdry. No. 3	108/6
" fdry. No. 1	111/6
Derbyshire forge	110/-
" fdry. No. 3	111/-
" fdry. No. 1	114/-
Scotland—	
Foundry, No. 1, f.o.t.	120/6
" No. 3, f.o.t.	118/-
Cleveland No. 3, Glasgow	112/-
" " Falkirk	109/-
Scottish hem. M/Nos. d/d	133/-
Sheffield (d/d district)—	
Derby forge	107/6
" fdry. No. 3	108/6
Lincs forge	107/6
" fdry. No. 3	108/6
W.C. hematite	138/6
Lancashire (d/d eq. Man.)—	
Derby fdry. No. 3	114/-
Staffs fdry. No. 3	114/-
Northants fdry. No. 3	112/6
Cleveland fdry. No. 3	114/-
Glengarnock, No. 3	137/6
Clyde, No. 3	137/6
Monkland, No. 3	137/6
Eglinton, No. 3	137/6
Gartsherrie, No. 3	137/6
Shotts, No. 3	137/6

(* Prices of hematite and basic pig-iron, and of foundry and forge iron with a phosphoric content of not less than 0.75 per cent., are subject to a rebate of 5s. per ton under certain conditions.)

FINISHED IRON AND STEEL

Usual district deliveries.

[A rebate of 15/- per ton for steel sections, plates and joists is obtainable in the home trade under certain conditions.]

Iron—	£	s.	d.	£	s.	d.
Bars (cr.)	13	5	0 to 13	15	0	
Nut and bolt iron	11	12	6 to 12	2	6	
Hoops				14	2	6
Marked bars (Staffs) f.o.t.				15	15	0
Gas strip				14	2	6
Bolts and nuts, ¾ in. × 4 in.				17	10	0 and up
Steel—						
Plates, ship, etc.	11	8	0 to 11	10	6	
Boiler plts.	11	18	0 to 12	0	6	
Chequer plts.				13	0	6
Angles				11	0	6
Tees				12	0	6
Joists				11	0	6
Rounds and squares, 3 in. to 5½ in.				12	0	6
Rounds under 3 in. to ¼ in. (untested)				12	4	0
Flats—8 in. wide and over				11	5	6
" under 8 in. and over 5 in.				11	10	6
Rails, heavy				10	2	6
Fishplates				14	2	6
Hoops (Staffs)				12	19	0
Black sheets, 24g. (4-t. lots)				15	15	0
Galv. cor. shts. (")				18	10	0
Galv. flat shts. (")				19	0	0
Galv. fencing wire, 8g. plain				20	5	0
Billets, soft, 100-ton lots				7	17	6
Sheet bars				7	15	0
Tin bars				7	15	0

PHOSPHOR BRONZE

Per lb. basis

Strip	10½d.
Sheet to 10 w.g.	11d.
Wire	12¾d.
Rods	12½d.
Tubes	18d.
Castings	15d.

Delivery 3 cwt. free.
10% phos. cop. £33 above B.S.
15% phos. cop. £38 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	7d. to 1/1
Rolled—	
To 9 in. wide	1/1 to 1/7
To 12 in. wide	1/1½ to 1/7½
To 15 in. wide	1/1½ to 1/7½
To 18 in. wide	1/2 to 1/8
To 21 in. wide	1/2½ to 1/8½
To 25 in. wide	1/3 to 1/9
Ingots for spoons and forks	7d. to 1/3½
Ingots rolled to spoon size	10d. to 1/6½
Wire round—	
to 10g.	1/4½ to 1/11½

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/3½ upwards.

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	25.84
No. 2 foundry, Valley	24.00
No. 2 foundry, Birm.	20.38
Basic, Valley	23.50
Malleable, Valley	24.00
Grey forge, Valley	23.50
Ferro-mang. 80%, seaboard	102.50
O.-h. rails, h'y, at mill	42.50
Billets	37.00
Sheet bars	37.00
Wire rods	47.00
	Cents.
Iron bars, Chicago	2.40
Steel bars	2.45
Tank plates	2.25
Beams, etc.	2.25
Skelp, grooved steel	2.10
Steel hoops	2.40
Sheets, black, No. 24	3.15
Sheets, galv., No. 24	3.80
Wire nails	2.75
Plain wire	2.90
Barbed wire, galv.	3.40
Tinplates, 100-lb. box	$5.35

COKE (at ovens)

Welsh foundry	40/- to 42/6
" furnace	32/6
Durham foundry	34/6
" furnace	30/-
Scottish foundry	40/-
" furnace	35/- to 37/6

TINPLATES

f.o.b. British Channel ports.

I.C. cokes	20×14 per box		20/3 to 21/6
"	28×20 "		40/6 to 43/-
"	20×10 "		29/-
"	18¾×14 "		21/-
C.W.	20×14 "		19/- to 20/3
"	28×20 "		38/- to 40/6
"	20×10 "		27/-
"	18¾×14 "		19/9 to 20/3

SWEDISH CHARCOAL IRON & STEEL

Pig-iron	£11	0	0 to £12	0	0	
Bars-hammered, basis	£20	0	0 to £22	0	0	
Bars and nail-rods, rolled, basis	£19	0	0 to £20	0	0	
Blooms	£18	0	0 to £19	0	0	
Keg steel	£30	0	0 to £35	0	0	
Faggot steel	£19	0	0 to £24	0	0	
Bars and rods dead soft st'l	£13	0	0 to £15	0	0	

All per English ton, f.o.b. Gothenburg
[Subject to an exchange basis of Kr. 19.39 to £1.]

DAILY FLUCTUATIONS

Standard Copper (cash)

	£	s.	d.		
June 23 ..	36	12	6	inc.	8/9
„ 24 ..	37	7	6	„	15/-
„ 27 ..	37	16	3	„	8/9
„ 28 ..	37	3	9	dec.	12/6
„ 29 ..	36	13	9	„	10/-

Electrolytic Copper

	£	s.	d.		
June 23 ..	41	0	0	inc.	15/-
„ 24 ..	41	5	0	„	5/-
„ 27 ..	41	15	0	„	10/-
„ 28 ..	41	15	0	No	change
„ 29 ..	40	15	0	dec.	20/-

Standard Tin (cash)

	£	s.	d.		
June 23 ..	186	5	0	inc.	20/-
„ 24 ..	187	10	0	„	25/-
„ 27 ..	187	5	0	dec.	5/-
„ 28 ..	185	5	0	„	40/-
„ 29 ..	184	0	0	„	25/-

Tin (English ingots)

	£	s.	d.		
June 23 ..	186	5	0	inc.	20/-
„ 24 ..	187	10	0	„	25/-
„ 27 ..	187	5	0	dec.	5/-
„ 28 ..	185	5	0	„	40/-
„ 29 ..	184	0	0	„	25/-

Spelter (ordinary)

	£	s.	d.		
June 23 ..	13	18	9	inc.	10/-
„ 24 ..	14	1	3	„	2/6
„ 27 ..	14	0	0	dec.	1/3
„ 28 ..	13	5	0	„	15/-
„ 29 ..	13	8	9	inc.	3/9

Spelter (Electro, 99.9 per cent.)

	£	s.	d.		
June 23 ..	17	15	0	inc.	8/9
„ 24 ..	17	18	9	„	3/9
„ 27 ..	17	17	6	dec.	1/3
„ 28 ..	17	2	6	„	15/-
„ 29 ..	17	6	3	inc.	3/9

Lead (soft foreign, prompt)

	£	s.	d.		
June 23 ..	14	17	6	inc.	1/3
„ 24 ..	14	17	6	No	change
„ 27 ..	15	1	3	inc.	3/9
„ 28 ..	14	7	6	dec.	13/9
„ 29 ..	14	6	3	„	1/3

Lead (English)

	£	s.	d.		
June 23 ..	17	0	0	No	change
„ 24 ..	17	0	0	„	„
„ 27 ..	17	5	0	inc.	5/-
„ 28 ..	16	10	0	dec.	15/-
„ 29 ..	16	10	0	No	change

AVERAGE MONTHLY PRICES OF UNMARKED BARS (SOUTH STAFFS)

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1903	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 7 0	6 5 0	6 9 4½
1904	6 5 0	6 5 0	6 5 0	6 5 0	6 10 0	6 5 0	6 0 0	6 0 0	6 0 0	6 0 0	6 0 0	6 0 0	6 2 11½
1905	6 5 0	6 5 0	6 0 0	5 17 6	5 15 0	5 15 0	5 15 0	5 15 0	6 0 0	6 5 0	6 15 0	6 15 0	6 1 10
1906	7 0 0	7 5 0	7 5 0	7 5 0	6 17 6	6 15 0	6 12 6	6 10 0	6 10 0	6 12 6	6 16 3	7 3 9	6 17 8
1907	7 3 9	7 5 0	7 5 0	7 5 0	7 5 0	7 7 6	7 5 0	7 7 6	7 7 6	7 7 6	7 7 6	7 5 0	7 5 11
1908	7 2 6	7 0 0	7 0 0	7 0 0	6 15 0	6 7 6	6 5 0	6 2 6	6 2 6	6 2 6	6 2 6	6 0 0	6 10 0½
1909	6 0 0	6 0 0	6 0 0	5 17 6	6 0 0	6 0 0	6 0 0	5 17 6	6 0 0	6 2 6	6 2 6	5 17 6	5 19 9
1910	6 2 6	6 3 4½	6 7 6	6 7 6	6 7 6	6 7 6	6 6 6	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 7
1911	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 10 0	6 12 6	6 16 6	6 7 6
1912	6 18 9	7 1 10	7 2 6	7 8 9	7 18 0	8 0 7	8 2 6	8 3 6	8 5 0	8 6 3	8 7 6	8 8 9	7 17 0
1913	8 11 6	8 10 7½	8 10 0	8 8 1½	8 2 0	8 0 0	7 17 6	7 11 6	7 8 9	7 5 6	6 18 1½	6 17 6	7 16 9
1914	6 17 6	6 15 7½	6 12 6	6 10 0	6 10 0	6 10 0	6 10 0	7 11 10½	8 0 0	7 12 6	7 5 7½	7 6 3	7 1 6
1915	7 11 6	8 5 11	8 8 9	9 6 0	10 3 2	10 19 2	11 12 6	11 13 1½	11 13 9	11 14 3	12 1 10½	13 0 9	10 6 0½
1916	13 7 6	13 10 8	13 12 9½	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 3 9
1917	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0½
1918	13 15 0	13 17 3	13 17 6	13 17 6	13 17 6	13 17 6	13 17 6	14 15 0	14 15 0	14 15 0	14 15 0	14 15 0	14 4 5
1919	15 10 0	16 5 0	17 15 0	17 15 0	20 15 0	21 0 0	21 0 0	22 0 0	22 0 0	22 0 0	22 7 6	22 12 6	20 1 8
1920	24 7 6	24 10 0	25 10 0	27 10 0	29 5 0	31 0 0	31 10 0	31 10 0	31 10 0	31 10 0	31 10 0	29 7 6	29 1 8
1921	26 17 3	25 0 0	23 0 0	21 0 0	19 0 0	18 5 0	16 0 0	16 0 0	15 14 0	14 0 0	13 6 8	13 0 0	19 4 5½
1922	13 0 0	12 3 9	11 14 0	11 11 10½	11 5 0	11 3 6	11 2 6	11 5 0	10 17 2½	10 16 3	10 13 0	10 12 6	11 7 0½
1923	10 16 10½	11 3 1½	12 2 6	12 8 9	12 11 6	12 1 3	11 15 11½	11 15 0	11 15 0	11 15 0	12 13 6	12 8 3	11 18 10½
1924	12 9 6	12 10 0	12 10 0	12 15 7½	12 17 6	12 17 6	12 17 6	12 17 6	12 17 6	12 14 0	12 12 6	12 12 6	12 14 3½
1925	12 12 6	12 12 6	12 12 6	12 12 6	12 12 6	12 7 6	12 7 6	12 7 6	12 4 6	11 18 6	11 13 9	11 13 9	12 6 2
1926	11 7 9½	11 5 0	11 5 0	11 5 0	11 5 0	11 3 9	11 3 9	11 5 0	12 0 0	13 0 0	*	15 7 6	12 19 0	12 0 2
1927	12 6 3	12 2 6	11 14 0	11 0 0	10 18 9	10 13 6	10 12 6	10 5 0	9 16 0	9 15 0	9 13 9	9 12 9	10 14 2
1928	9 12 6	9 12 6	9 11 0	9 10 0	9 8 4	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 3 6	9 1 3	9 7 0
1929	9 0 0	9 2 6	9 5 7½	9 9 4½	9 10 0	9 17 6	10 2 6	10 2 6	10 2 6	10 0 6	10 3 9	10 5 7	9 15 2½
1930	10 7 6	10 7 6	10 7 6	10 6 10½	10 6 3	10 5 0	10 2 6	10 2 6	10 2 6	10 2 6	10 2 6	10 2 6	10 4 7½
1931	10 2 6	10 0 0	10 0 0	10 0 0	9 18 1½	9 17 6	9 17 6	9 17 6	9 17 6	9 17 6	9 17 6	9 16 10½	9 18 0½
1932	9 15 0	9 15 0	9 15 0	9 15 0	9 13 9	9 11 3	9 10 0	9 10 0	9 10 0	9 6 3	9 5 0	9 5 0	9 10 11½
1933	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0
1934	9 5 0	9 8 1½	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 11 6
1935	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6
1936	9 12 6	9 15 0	10 2 6	10 2 6	10 2 6	10 2 6	10 6 3	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 4 5½
1937	10 10 0	10 10 0	11 17 6	11 17 6	11 17 6	11 17 6	12 4 6	13 5 0	13 5 0	13 5 0	13 5 0	13 5 0	12 4 11½
1938	13 5 0	13 5 0	13 5 0	13 5 0	13 5 0	13 5 0	—	—	—	—	—	—	—

* No quotation available owing to strike.

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WINCHESTER HOUSE, OLD BROAD ST., LONDON, E.C.2.

CLARENCE CHAMBERS, 39, CORPORATION STREET, BIRMINGHAM.

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PIG IRON

REGISTERED TRADE MARK

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All grades FOUNDRY, HEMATITE, BASIC, SPECIALS, &c.

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COPPER, TIN, LEAD, SPELTER, ANTIMONY, CHROME ORE.

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SITUATIONS VACANT AND WANTED

EXECUTIVE POSITION, iron or steel industry, sought by Accountant (Chartered Secretary) (27). Held position Secretary/Accountant large manufacturing company. Thoroughly experienced at preparation manufacturing accounts; sound knowledge foundry practice, costs. Accustomed to responsible post, experienced all board matters. First class references.—Box 108, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

FOUNDRY REQUISITES.—Advertiser with thorough practical knowledge of foundry trade (twenty years' managerial experience) wishes to represent a first-class firm making foundry requisites. Replies in strict confidence to: Box 978, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

AN opening occurs on the Works Staff of a large Engineering and Foundry Company in the South of England in connection with the further development of a special foundry process.

The position calls for a man with pattern-maker training and experience, and a good all-round knowledge of, and preferably, but not essentially, practical experience in the various moulding methods commonly used in the production of general castings in Non-Ferrous metals, particularly Aluminium Alloys, and also a comprehensive knowledge of Moulding Sands, their treatment and methods of control.

The duties will include supervision of certain applications of the process in collaboration with the Shop Foreman, to systematically study the process referred to, and to interview customers and others relative to the application of the process.

This is a good opening for a progressive man with the requisite experience, who is tactful and of good address.

The salary will be according to ability.

Applicants must give age, particulars of technical education, broad details of experience, including names of past and present employers.

All applications, which will be treated as confidential, should be addressed to: Box 110, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

UNDER-FOREMAN Brass Moulder wanted in Glasgow area to control approximately twenty hands at tub work producing fine light castings in gunmetal and aluminium alloy. Salary £6 per week to suitable man. Apply stating training and experience.—Box 114, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

FOUNDRY Chemist or Metallurgist, young, required to act as Technical Salesman. Apply in writing, stating age, experience, and salary required to: THOMAS & ISAAC BRADLEY, LTD., Heath Road, Darlaston.

FOUNDRY WORKING FOREMAN required to work up good business for small firm employing seven moulders. Must have thorough knowledge of cupola, mixing of metals for high-grade engineering castings, special metal melted by oil furnaces. State age, wages required.—Box 104, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

ROLL FOUNDRY Production Manager required for large modern plant manufacturing all types of sand, chill and heat-treated rolls. Must be conversant with modern practice. State age, experience and salary.—Box 112, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

WANTED.—Traveller, 30-40, with good connection amongst foundries in Derbyshire, North Staffs and Nottinghamshire areas, sales personality, good appearance, for permanent post, Pig-irons, Refractories, Sands, etc. Excellent prospects. Knowledge of mentioned products not essential, but an advantage. State full experience, salary, etc.—Box 106, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

SITUATIONS VACANT AND WANTED—*Contd.*

WANTED.—Experienced Chemist to take charge of Core and Mould Sand Mixing, at a large foundry specialising in car part production. Good prospects for the right man.—Apply Box 988, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

WANTED.—Foundry Foreman for light foundry using moulding machines and synthetic sand. Should be used to rotary oil furnace and annealing.—Apply CWMBRAN ENGINEERING CO., LTD., 19, Palace Street, London, S.W.1.

PARTNERSHIP

WORKING PARTNER with small capital wanted in small Cornish foundry. Spendid opportunity for a man who can introduce work. Fullest investigation invited.—Reply Box 100, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

AGENCY

ACTIVE AGENT with first-class connection, constantly covering London and 50 miles radius, seeks additional line, preferably Small Repetition Grey Iron or Brass Castings. Results absolutely guaranteed. Only well-established firms able to cope with substantial quantities entertained.—Box 856, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

MACHINERY

'Phone **98** Staines.

VERTICAL Crosstube Boiler, 10 ft. by 5 ft. 6 in., 100 lbs. w.p.
Screwing Machine, up to 6-in. pipe.
Ingersoll Rand Compressor, Type 14.
Air Receiver, 6 ft. 6 in. by 2 ft. 6 in., 100 lbs. pressure.

HARRY H. GARDAM & CO., LTD.,
STAINES.

SANDBLAST PLANTS.

ROOMS size, 12 ft. by 12 ft., 12 ft. by 9 ft., and 6 ft. by 6 ft.
Barrels: 54 in. by 36 in.; 36 in. by 30 in.; 30 in. by 20 in., etc.
Cabinet: 6 ft. by 4 ft.; 4 ft. 6 in. sq. by 3 ft. 6 in. sq., and 30 in. dia.
Table: 9-ft. Guttman.
Air Compressors in stock to suit any of the above plants.
Sand Mills: 7 ft. 6 in., 7 ft., 6 ft., 5 ft. and 4 ft. dia. pans.
Cupolettes: 10 cwts., 15 cwts. and 20 cwts.
Cupolas: 2 and 3 tons.
Morgan Tilting Furnaces: 250 and 400 lbs.
Heavy D.E. Grinding Machine: wheels 24 in. by 4½ in.
Sand Rammers, Disintegrators and Mixers. Air Compressors, Blowers and Exhaust Fans, Moulding Machines, etc., etc.

S. C. BILSBY, A.M.I.C.E., A.M.I.E.E.,
CROSSWELLS ROAD (Adjoining Railway Crossing), LANGLEY, Nr. Birmingham.
'Phone: Broadwell 1359.

THOS. W. WARD, LTD.

15-ton Double-geared FOUNDRY LADLE (Jos. Evans), 6′ dia. across top x 6′ deep; ½″ plate; band round middle of body, 10″ x 1″; top band, 8½″ x ¾″; uprights, 3″ dia.; tipping gear consists of 40″ dia. worm wheel with worm operated through bevel reduction gear; top beam, 14″ x 1½″.

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Write for "Albion" Catalogue.
ALBION WORKS, SHEFFIELD.
'Grams: "Forward." 'Phone: 23001 (10 lines).

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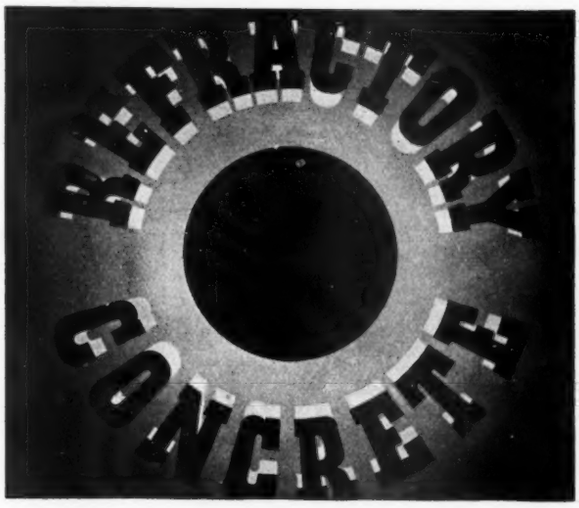

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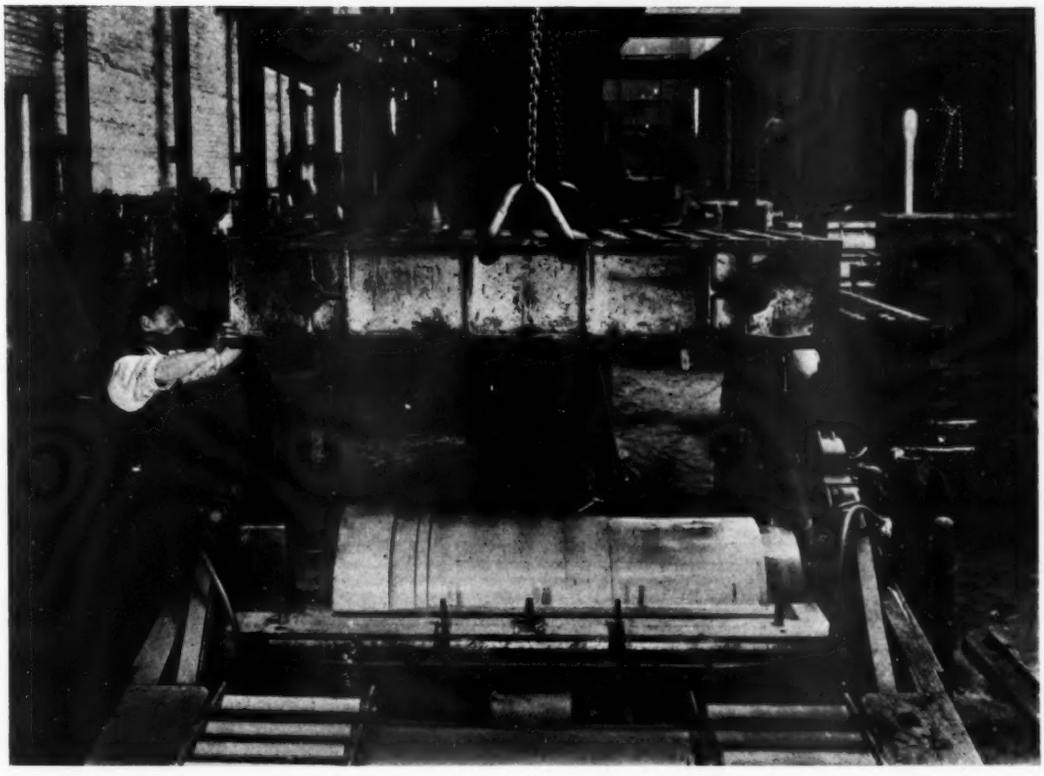

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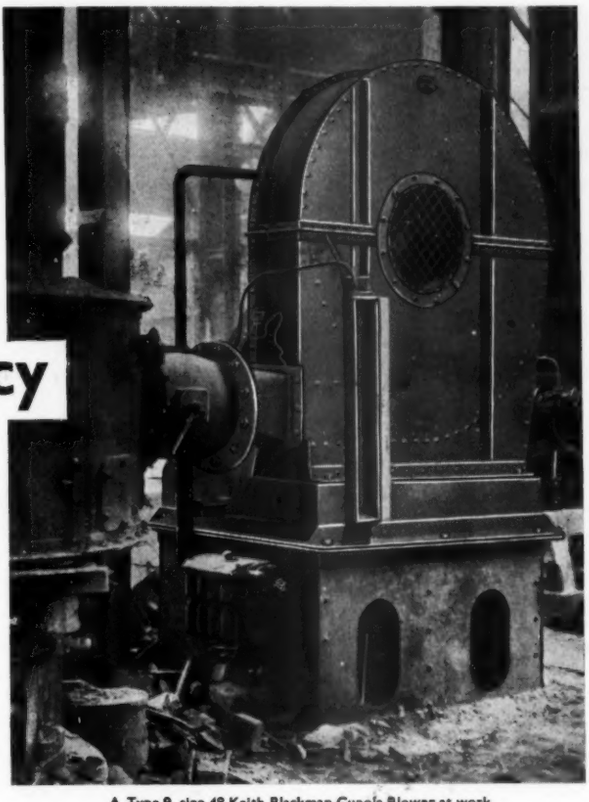

A Type 9, size 48 Keith Blackman Cupola Blower at work at the Wallsend Slipway & Engineering Co. Ltd.

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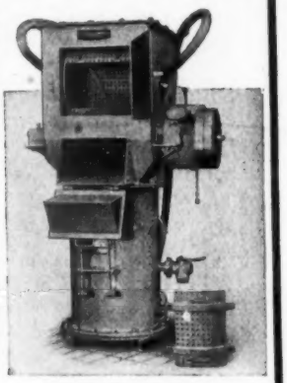

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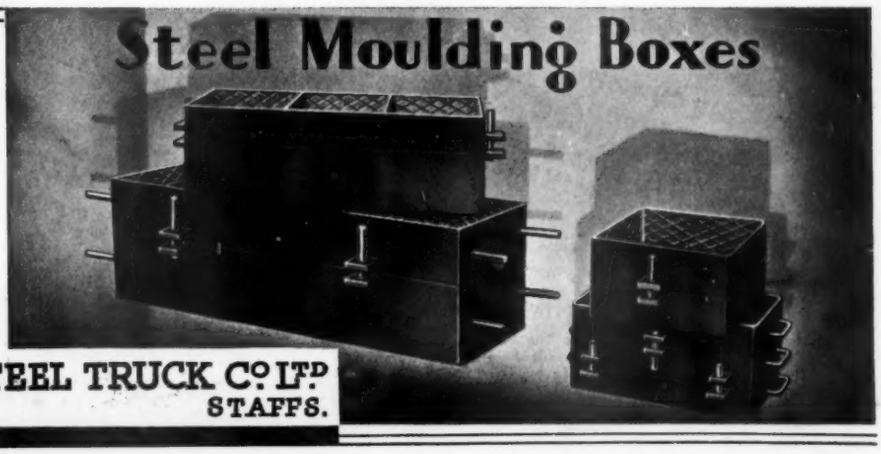

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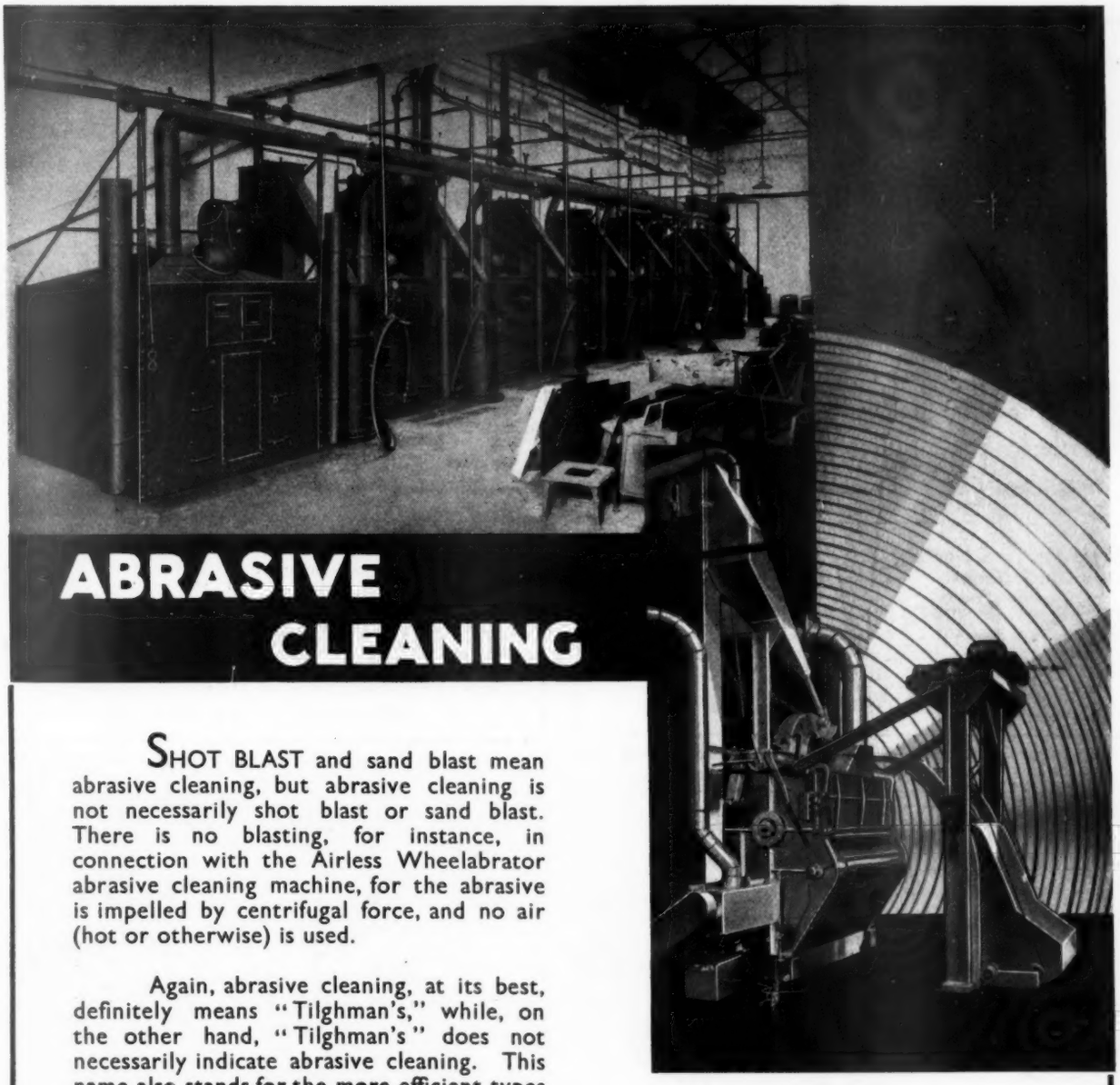

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